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Evaluation of Nutritional Composition and Total Polyphenols Content in Avocado Seed (*Persea americana*)

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Abstract

Avocado (*Persea americana*) is a fruit recognized for its high nutritional value and rich content of bioactive compounds. The avocado seed, a by-product of pulp processing, presents a complex composition, including proteins, fats, fibers, ash, carbohydrates, and water, alongside bioactive compounds such as flavonoids, tannins, saponins, total phenolics, oxalates, phytates, alkaloids, vitamins, and minerals. The aim of this study was to nutritionally evaluate the nutritional and total phenolic content of avocado seed (Persea americana), with a view to its potential use as a food additive or as a material for active packaging with antioxidant properties.

Results showed values ranging from 11.31–14.42% for moisture, 2.11–3.42% for ash, 4.37–5.32% for protein, 11.10–12.31% for fat, 3.96–6.64% for crude fiber, 51.81–55.82% for carbohydrates, and 28.62–31.58 mg GAE/g d.m. for total phenolic content (TPC).

These values confirm that avocado seed powder is a valuable source of nutritional and bioactive compounds, with potential applications as a functional ingredient or as a base material for biodegradable and active food packaging. The valorization of this by-product also contributes to reducing food waste and minimizing the environmental impact of agro-industrial residues.

Keywords: avocado seed, nutritional parameters, total polyphenols, functional ingredient, active packaging

1. Introduction

Avocado (*Persea americana*) is widely valued for its high content of nutritional and bioactive compounds, which contribute to its recognized health-promoting properties [1]. These compounds are unevenly distributed across different fruit tissues. In the 'Hass' variety, Xin et al. (2025) reported significant compositional differences among the pulp, seed, and peel on a fresh weight (FW) basis.

The pulp contained 75.63% moisture, 1.64% ash, 18.95% crude fat, 2.53% crude fiber, 1.14% total acids, 2.28% protein, and 3.31 g total sugars. The seed exhibited lower moisture (52.37%) but higher levels of crude fiber (5.58%) and total sugars (8.11 g), alongside 1.21% ash, 3.36% fat, 1.18% total acids, and 2.77% protein. The peel was characterized by 64.45% moisture, 1.63% ash, 2.68% fat, notably higher crude fiber (16.33%), 0.73% total acids, 1.60% protein, and 3.13 g total sugars [2].

Bioactive compound profiles also varied markedly among tissues. The seed showed the highest concentrations of total polyphenols (2343.61 ± 31.44 mg/100 g), flavonoids

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(2645.59 mg/100 g), procyanidins (485.76 mg/100 g), tannins (1043.33 mg/100 g), catechin (4.45 mg/g), and quercetin (259.49 µg/g). The peel presented intermediate levels (e.g. 1055.23 mg/100 g polyphenols; 521.49 mg/100 g flavonoids), whereas the pulp had significantly lower concentrations, except for terpenoids (1717.37 mg/100 g) and polysaccharides (0.47 g/100 g), which reached their highest levels in this tissue. Quercetin was not detected in the pulp [2].

These findings confirm that, although the pulp constitutes the main source of lipids and terpenoids, the fruit by-products - particularly the seed and peel - represent valuable sources of phenolic compounds and natural antioxidants. This characteristic supports the growing interest in the valorization of these secondary fruit tissues for functional and nutraceutical applications, thereby contributing to waste reduction and the sustainable use of plant resources.

The avocado seed, which represents between 13% and 17% of the fruit's total weight and is considered a by-product of pulp processing, contains a wide range of bioactive compounds and essential nutrients. It is rich in proteins, lipids, minerals, vitamins, polysac charides, and various bioactive compounds such as phenols, flavonoids, and condensed tannins, which have been associated with anti-inflammatory, antimicrobial, antihyperglycemic, and antioxidant properties [3, 4, 5, 6, 7].

Findings from the scientific literature highlight a significant variability in the chemical composition of avocado (*Persea americana*) seeds, largely influenced by factors such as cultivar, geographical origin, fruit maturity, and drying or processing method [8, 9]. Key nutritional parameters - including moisture, ash, protein, lipids, fiber, and carbohydrates - show wide variations, confirming the structural complexity and commercial potential of this agro-industrial by-product.

Comparative data analysis further indicates considerable variability in the chemical composition of avocado seeds, determined by cultivar, pedoclimatic conditions, harvest maturity, and processing techniques. This diversity underscores the potential for utilizing avocado seeds as a source of nutritional and bioactive compounds, despite their frequent classification as agro-food waste.

Moisture content ranges from 6.21% [10] to 67.20% [11], with intermediate levels of 13–15% in oven-dried samples [12, 13] and 30–35% in partially dehydrated samples [14, 15]. Lower moisture levels are associated with improved microbiological stability, favorable for storage and industrial use.

The mineral fraction (ash) ranges from 1.10% to 3.82%, indicating a potential contribution of macro- and microelements [16, 17].

Protein content also varies widely, from 0.20% [18] to 23.0% [4, 18], with higher values typically observed in samples subjected to mild drying (45–60 °C), which helps preserve protein integrity.

The lipid fraction ranges from 0.33% [17] to 18.0% [4], comprising unsaturated fatty acids (oleic, linoleic, palmitoleic) beneficial to cardiovascular health and valuable to the cosmetic industry.

Crude fiber content varies between 1.83% [3] and 10.7% [11], contributing to the seed's digestive functional properties.

Carbohydrates represent the dominant fraction (32.0–83.8%) and include polyphenols and tannins with strong antioxidant activity (Siol and Sadowska, 2023; Pușcaș *et al*., 2022) [15, 19].

The literature also reveals substantial variability in the total polyphenol content (TPC) of avocado seeds, influenced by cultivar, moisture content, solvent type, and extraction technique. Reported values range from 29.17 mg GAE/100 g DM [7] to 18,000 mg GAE/100 g DM [20], reflecting major methodological differences. Tremocoldi et al. (2018) reported high concentrations for the Fuerte (5920 mg/100 g DW) and Hass (5730 mg/100 g DW) varieties [21], whereas Kosińska *et al.* (2012) obtained much lower values for Shephard (1304 mg/100 g DW) and Hass (951 µg/g DW) [22]. Recent studies confirm that avocado seeds contain substantial amounts of phenolic compounds (3000–6000 mg GAE/100 g DM) [6, 19], predominantly flavonoids and condensed tannins, comparable to or even exceeding the levels found in the pulp.

In conclusion, the avocado seed exhibits a complex composition characterized by the presence of proteins, lipids, ash, fibers, carbohydrates, moisture, and a wide range of bioactive compounds - including flavonoids, tannins, saponins, total polyphenols, oxalates,

phytates, alkaloids, vitamins, and minerals. This chemical diversity highlights the potential of the avocado seed as a promising source of nutrients and natural antioxidants, with significant applications in the food, pharmaceutical, and nutraceutical sectors, contributing to the sustainable valorization of agro-industrial by-products [19]. Exploring the dietary and therapeutic uses of avocado seeds, typically regarded as secondary products, may represent an effective strategy for reducing environmental impact [7].

Previous studies have shown that this component, often considered a by-product, serves as a valuable source of nutrients and bioactive compounds with potential utility in various functional and technological applications.

Based on these premises, the aim of the present study was to obtain and characterize the nutritional profile of the avocado seed (kernel), as well as to evaluate its total polyphenol content, with the goal of valorizing it as a food additive or as a base material for developing active packaging with antioxidant properties. Preliminary results, expressed on a dry weight basis, indicated that the avocado seed contains 11.31–14.42% moisture, 2.11–3.42% ash, 4.37–5.32% protein, 11.10–12.31% fat, 3.96–6.64% crude fiber, 51.81–55.82% carbohydrates, and a total polyphenol content (TPC) ranging from 28.62 to 31.58 mg GAE/g dry matter (DM).

These findings support the hypothesis that avocado seeds possess a balanced chemical composition and a significant level of phenolic compounds, which recommend them as natural ingredients with functional value [10, 23]. Therefore, their detailed analysis provides a solid foundation for future use as a food additive or as a component in active packaging materials with antioxidant properties, contributing to the sustainable utilization of plant resources [3].

2. Materials and methods

2.1. Materials

For the preparation of avocado seed samples, commercially imported avocado fruits were purchased from local specialized stores. Fruits without biological or mechanical damage, randomly selected from three different locations, were used to obtain the three sample batches labeled P1, P2, and P3. First, the fruits were washed under running tap water and then wiped with a paper towel, after which the seed (kernel) was separated from the pulp. The seeds were manually removed from the fruits, rinsed with distilled water, cut into small pieces, and dried in an oven at 50°C until constant weight. The dried seeds were then ground into avocado seed powder (ASP) using a kitchen grinder and stored in airtight containers for subsequent analyses.

2.2. Methods

Standardized analytical methods recommended by AOAC (2000) and Velciov *et al*. (2022) were applied to determine the nutritional parameters, including moisture, ash (mineral content), protein, fat, crude fiber, and carbohydrates [24, 25].

More specifically, moisture content was determined by drying the avocado seed powder in an oven at 105°C to constant weight. Ash content was determined by calcination at 550°C. Protein content was measured using the Kjeldahl method, applying a nitrogen-to-protein conversion factor of 6.25. Crude fat was quantified using the Soxhlet extraction method with hexane as solvent. Crude fiber content was determined using the acid–alkali digestion method. Carbohydrate content was calculated by difference.

The total polyphenol content (TPC) was evaluated using the Folin-Ciocalteu method, as described by Negrea *et al*. (2025) [26].

Preparation of ethanolic extracts

For the preparation of ethanolic extracts (70%, v/v), 1 g of avocado seed powder was mixed with 10 mL of 70% ethanol in sealed containers. The mixtures were magnetically stirred for 30 min and then filtered through Whatman No. 1 filter paper. The resulting filtrates were used to determine total polyphenol content and antioxidant activity.

Determination of total polyphenol content (TPC)

A volume of 0.5 mL of extract was mixed with 1.25 mL of Folin-Ciocalteu reagent (diluted 1:10) and allowed to react for 5 min at room temperature. Subsequently, 1 mL of Na_2CO_3 solution (60 g/L) was added, and the samples were incubated at 50°C for 30 min. Absorbance was measured at 750 nm using a UV–VIS spectrophotometer.

For calibration, standard solutions of gallic acid (Fluka, Madrid, Spain) with concentrations

ranging from 20 to 200 mg/L were used. Results were calculated from the gallic acid calibration curve and expressed as mg gallic acid equivalents (GAE)/g dry matter (DM).
All analyses were performed in triplicate, and the results were reported as mean values ± standard deviation (SD).

3. Results and discussions

The results obtained for the determination of nutritional compounds and total polyphenol content in the composite avocado seed samples are presented in Tables 1 and Figure 1.

Table 1. Nutritional composition of avocado seed powder expressed, in %, dry matter (%, DM).

Specification	Sample P1	Sample P2	Sample P3
Moisture	14.42±0.36	11.31±0.32	12.92±0.37
Ash	2.11±0.19	3.42±0.22	2.81±0.21
Protein	4.37±0.25	5.32±0.27	4.88±0.29
Fat	11.10±0.37	12.31±0.50	11.87±046
Crude fiber	6.64±0.27	3.96±0.28	5.38±0.26
Carbohydrate	51.81±1.45	55.82±1.76	53.31±1.97

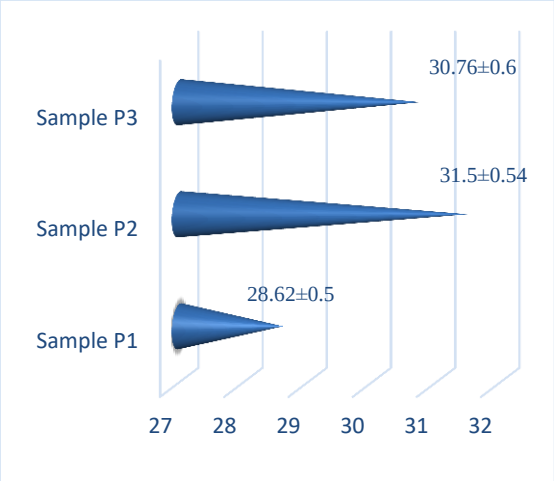

Figure 1. The total polyphenol contents (TPC) in avocado seed powder, expressed as mg GAE/g dry matter (DM).

The comparative analysis of the nutritional composition of avocado seeds from three local vendors (samples P1, P2, and P3) revealed moderate differences in the measured parameters, likely influenced by fruit origin, maturity, drying, and grinding conditions.
Moisture content ranged from 11.31% (P2) to 14.42% (P1), with an intermediate value of 12.92% for P3. These variations indicate differences in water content among the samples. The lower value observed in P2 suggests higher stability during storage, whereas P1, having the highest moisture content, may be more prone to microbiological degradation. Sample P3, with an intermediate level, reflects an optimal balance between stability and preservation of sensory properties.
Ash content, reflecting total mineral concentration, ranged from 2.11% (P1) to 3.42% (P2), with P3 showing an intermediate value of 2.81%. This suggests that P2 has a higher mineral content, possibly due to differences in soil composition or fruit cultivar.
Protein content varied from 4.37% (P1) to 5.32% (P2), with P3 at an intermediate 4.88%. These results indicate a modest but consistent protein contribution across the samples, with P2 showing the highest content and a slight nutritional advantage.
The lipid fraction ranged from 11.10% (P1) to 12.31% (P2), with P3 having a value close to the mean (11.87%). The relatively high fat content confirms the presence of avocado seed-specific fatty acids, particularly unsaturated ones, with potential health benefits. The small differences among samples indicate a stable lipid composition.
Crude fiber content was highest in P1 (6.64%), followed by P3 (5.38%) and lowest in P2 (3.96%). This suggests that P1 powder has the greatest potential for use in functional products aimed at improving digestion, whereas P2 presents a more balanced profile suitable for products requiring a finer texture.
Carbohydrates, the major fraction, ranged from 51.81% (P1) to 55.82% (P2), with P3 at an intermediate 53.31%. These differences indicate slight variations in total energy content, with P2 potentially offering the highest caloric value.
Overall, P2 stands out for its balanced nutritional profile (higher protein, fat, and mineral content), P1 for its high fiber content, and P3 occupies an intermediate position, combining characteristics of the two extremes.
In general, the chemical composition of the analyzed samples aligns with trends reported in the literature, with values falling within previously published ranges. Observed variations can be explained by fruit biological diversity, processing conditions (temperature

and drying method), and geographical origin of the biological material.

Total polyphenol content (TPC) is a key indicator in evaluating the quality and functional value of avocado seeds. Polyphenols are recognized for their antioxidant, anti-inflammatory, and protective effects against oxidative stress, playing a significant role in health promotion and enhancing the functional value of foods [26].

The TPC results, expressed as mg gallic acid equivalents per gram of dry matter (mg GAE/g DM), showed significant variation among the three samples. Values were 28.62 ± 0.58 mg GAE/g DM for P1, 31.58 ± 0.54 mg GAE/g DM for P2, and 30.76 ± 0.51 mg GAE/g DM for P3. Among the three samples, P2 exhibited the highest total polyphenol content, followed by P3 and P1. The difference of approximately 3 mg GAE/g DM between P2 and P1, although seemingly modest, may be considered significant in terms of antioxidant capacity and the biological activity of the analyzed products.

The analysis of total polyphenol content (TPC) in the three avocado seed powder samples (P1, P2, and P3) allowed a comprehensive assessment of their nutritional and functional value. Avocado seed powders are a promising source of bioactive compounds, and TPC serves as a key indicator of antioxidant potential, directly influencing product stability, quality, and functional properties.

The results confirm the potential of avocado seeds as a source of valuable nutrients, comparable to other plant-based sources. Moisture content (11.31–14.42%) fell within ranges reported in previous studies, closely matching values reported by Ejiofor *et al.* (2018) – 15.10% [12], Kolawole (2025) – 14.64% [13], and Mahawan *et al.* (2015) – 14.05% [27], but substantially lower than values reported by Flores *et al.* (2019) [16] and Vinha et al. (2013) [28] for fresh material (54–58%), confirming the efficiency of the drying process used in this study.

Ash content (2.11–3.42%) was comparable to previous reports: Ifesan *et al.* (2015) – 2.4% [18], Mahawan *et al*. (2015) – 2.83% [27], and Egbuonu *et al*. (2018) – 3.82% [17], indicating a moderate-to-high mineral concentration. The maximum value (P2 = 3.42%) suggests potential mineral enrichment, similar to air-dried powders from Nigeria [17]. According to Wanjiru *et al*. (2025), 100 g of avocado seeds contain 264.7–848.6 mg K, 0.16–0.43 mg Na, 0.05–0.18 mg Ca, 16.6–34.5 mg Mg, 0.43–0.79 mg Zn, 0.049–0.160 mg Fe, and 0.0079–0.017 mg Cu [29].

Protein content (4.37–5.32%) was lower than reported by Ifesan *et al.* (2015) – 23.0% [18] and Arukwe et al. (2012) – 17.94% [30], but comparable to Mahawan *et al.* (2015) – 7.75% [27] and Nyakang'i *et al*. (2023) – 7.05% [5], which used Hass variety and similar drying conditions (60°C, 5 h). Differences can be attributed to varietal variation and basis of expression (fresh vs. dry weight).

Fat content (11.10–12.31%) was similar to Kolawole (2025) – 13.31% [13] and Ejiofor *et al.* (2018) – 17.90% [12], but higher than Mahawan *et al.* (2015) – 0.71% [27] and Egbuonu *et al*. (2018) – 0.33% [17], likely due to the variety used and higher lipid extraction in well-dried powders.

Crude fiber (3.96–6.64%) was comparable to Mahawan *et al.* (2015) – 4.91% [27] and Nyakang'i *et al.* (2023) – 4.0% [5], but lower than the high values reported by Omolara *et al.* (2017) – 26.33% [14] on partially wet material, indicating a higher degree of refinement in the powders obtained in this study.

Carbohydrate content (51.81–55.82%) aligned with Kolawole *et al.* (2025) – 48.51% [13], Imafidon *et al.* (2025) – 52.98% [3], and Omolara *et al.* (2017) – 54.23% [14], confirming that carbohydrates constitute the predominant fraction of avocado seed powder. Higher values (>70%) reported by Mahawan et al. (2015) [27] and Munoz-Gimena *et al.* (2025) [10] likely reflect methodological differences in dry matter calculation.

TPC values determined in this study (28.62–31.58 mg GAE/g DM) indicate a moderate polyphenol content, comparable to literature data for dry seed samples. These values are lower than those reported by Tremocoldi *et al.* (2018) for Fuerte and Hass varieties (57.3–59.2 mg GAE/g DM) [21], Siol & Sadowska (2023) – 62.1 mg GAE/g DM [19], and Nascimento et al. (2025) – 45–180 mg GAE/g DM [20], as well as lower than concentrated extracts analyzed by Féliz-Jiménez *et al*. (2024) [9] (60–1303 mg GAE/g extract). Conversely, the values obtained exceed those reported by Kosińska et al. (2012) – Shepherd

variety (13.04 mg GAE/g DM) [22], Ifesan et al. (2015) – 5.3 mg GAE/g DM [18], Kolawole et al. (2025) – 1.51 mg GAE/g DM [13], Bahru et al. (2019) – 0.29 mg GAE/g DM [7], and fresh samples such as Vinha *et al.* (2013) – 7.04 mg GAE/g FW [28] and Pușcaș *et al.* (2022) – 7.73 mg GAE/g FW [15].

Overall, the TPC values obtained are moderate and comparable with reports from Flores *et al.* (2019) – 36.41 mg GAE/g extract [16], Nyakang'i et al. (2023) [5], and Xin *et al.* (2025) – ≈24.35 mg GAE/g DM [2]. These results confirm that total polyphenol content depends on factors such as fruit variety, environmental conditions, maturity, and processing and extraction methods [6, 9, 21].

Overall, the TPC determined in avocado seeds suggests significant antioxidant potential, which, together with other bioactive compounds such as flavonoids, may contribute to the beneficial biological activity of food products in which they are incorporated. Therefore, the analyzed powders can be considered functional ingredients with added value, acting as natural antioxidant additives in the development of health-promoting foods [19].

Numerous studies have highlighted the potential of avocado seeds (Persea americana Mill.) as a source of starch for biodegradable materials. Tesfaye *et al.* (2021) reported starch contents of up to 60% relative to fruit weight [31], while Muñoz-Gimena *et al.* (2025) and Pires *et al.* (2024) reported values ranging from 7.8% to 29.3% and approximately 27.7% (DM), respectively [10, 32]. These data confirm that avocado seeds can serve as a viable raw material for the development of biopolymer films compatible with conventional processing technologies [10].

The results of the present study support these findings, with the analyzed avocado seeds exhibiting high carbohydrate content (51.8–55.8%), approximately 25–30% of which is starch, providing favorable film-forming properties. Moderate protein and fat contents contribute to improved film strength and flexibility, while the presence of phenolic compounds (28.6-31.6 mg GAE/g dry matter) confers significant antioxidant and antimicrobial potential.

In the presence of glycerol as a plasticizer and a food-grade spice with antioxidant and aromatic properties, such as cinnamon or cardamom, avocado seed powder demonstrated the ability to form flexible, stable, and bioactive films [10]. These films may extend the shelf-life of food products by reducing oxidative processes and limiting microbial growth. In line with the literature, the results confirm the potential use of avocado seeds as a sustainable source of biopolymers for the development of biodegradable and functional packaging, meeting current sustainability demands in the food industry.

5. Conclusion

The results demonstrate that avocado seeds (*Persea americana*), although considered a by-product, represent a valuable source of nutritional and bioactive compounds. The obtained powder exhibited a balanced composition: 11.31–14.42% moisture, 2.11–3.42% ash, 4.37–5.32% protein, 11.10–12.31% fat, 3.96–6.64% crude fiber, and 51.81–55.82% carbohydrates. Total polyphenol content (28.62–31.58 mg GAE/g dry matter) indicates significant antioxidant potential.

Moderate variability among the analyzed samples (P1–P3) can be attributed to fruit origin, maturity, and processing conditions, yet the values are consistent with literature data. Sample P2 stood out for its most balanced nutritional profile and highest polyphenol content.

The determined values align with those reported in the literature, confirming that avocado seeds represent an alternative resource with nutritional and functional value comparable to other plant sources rich in phenolic compounds. Consequently, avocado seed powder can be utilized either as a functional food ingredient with antioxidant properties or as a raw material for the development of biodegradable films and active packaging.

Future research should focus on the formulation of value-added foods enriched with avocado seed powder, as well as the optimization of technological processes to preserve bioactive compounds. Valorization of this resource also contributes to reducing waste from avocado processing and promotes sustainability across the agro-food chain.

Conflicts of interest No conflict of interest

Ethics approval: No ethic situation.

References

1. Nwaokobia, K., Oguntokun, M.O., Okolie, P.L., Ogboru, R.O., Idugboe, O.D., Evaluation Bioactive Antioxidants from Avocado By-Products: Mechanistic Study and Laboratory-Scale Extraction Optimization, *Antioxidants*, **2025,** 14, 1225. https://doi.org/10.3390/antiox14101225.
3. Imafidon, M. I., Omozuwa, P. O., Imafidon, G., Phytochemical screening and chemical study of *Persea americana* (avocado) seed, *Dutse Journal of Pure and Applied Sciences*, **2025**, 11(1d), 147–157.
4. Robin, S. J., Balakumbahan, R., Rajesh, S., Muthulakshmi, S., Anitha, T., Exploring the bioactive components and their pharmacological prospects in Avocado (*Persea americana* Mill.). *Annals of Phytomedicine*, **2024**. 13(2).
5. Nyakang'i, C.O., Marete, E., Ebere, R., Arimi, J.M., Physicochemical properties of avocado seed extract model beverages and baked products incorporated with avocado seed powder. *International Journal of Food Science*, **2023**(1), 6860806.
6. Lyu, X., Agar, O.T., Barrow, C.J., Dunshea, F.R., Suleria, H.A.R., Phenolic Compounds Profiling and Their Antioxidant Capacity in the Peel, Pulp, and Seed of Australian Grown Avocado, *Antioxidants* **2023**, 12, 185. https://doi.org/ 10.3390/antiox12010185
7. Bahru, T. B., Tadele, Z. H., Ajebe, E. G., A review on avocado seed: Functionality, composition, antioxidant and antimicrobial properties. *Chemical Science International Journal*, **2019**, 27(2), 1-10.
8. Ogutu, F., Obong'o, B.O., Thaari, W.M., Langat, J.K., Nyaguti, W.A., Okiko, G.M., ... & Maringa, C.W., Nutritional Composition of Hass Avocado (*Persea americana* Mill) Cultivated in Major Growing Areas in Kenya. *International Congresses of Turkish Science and Technology Publishing*, **2025**, 1132-1140
9. Féliz-Jiménez, A., Sanchez-Rosario, R., Bioactive Compounds, Composition and Potential Applications of Avocado Agro-Industrial Residues: A Review, *Appl. Sci.* **2024**, 14, 10070. https:// doi.org/10.3390/ app142110070
10. Munoz-Gimena, P.F., Aragon-Gutierrez, A., Blazquez-Blazquez, E., Arrieta, M.P., Peponi, L., Lopez, D., Valorization of Avocado Seeds for Active Packaging: Comparative Analysis of Extracted Starch- and Seed Flour-Based Materials with Cinnamon Essential Oil., *Polysaccharides*, **2025**, 6(83). https://doi.org/ 10.3390/ polysaccharides6030083
11. Morais, D.R., Rotta, E.M., Sargi, S.C., Bonafe, of the chemical composition of *Persea americana* (Mill) pulp and seed, *Journal of Bioscience and Biotechnology Discovery*, **2018**, 3(4), 83–89.
2. Xin, Z., Gao, Y., He, L., Xiu, Z., Sun, L., E.G., Suzuki, R.M., Souza, N.E., Matsushita, M., Visentainer, J.V., Proximate Composition, Mineral Contents and Fatty Acid Composition of the Different Parts and Dried Peels of Tropical Fruits Cultivated in Brazil, *J. Braz.Chem. Soc.*, **2017**, 28, 308–318.
12. Ejiofor N.C., Ezeagu I.E., Ayoola. M., Umera, E.A., Determination of the chemical composition of avocado (*Persea americana*) seed., *Adv Food Technol Nutr Sci Open J.*, **2018**, SE (2), S51-S55. doi: 10.17140/ AFTNSOJSE-2-107
13. Kolawole, S., Obueh, H., Onwuegbule, E., Comparative Study of the Proximate, Mineral and Phytochemical Compositions of Avocado (Persea americana) Pulp and Seed, *J.Food Pharm.Sci.* **2025**, 13(2), 112-121
14. Omolara, O.O., Friday, O.N., Chinelo, M.O., Comparative study of the constituents of the fruits pulps and seeds of *Canarium ovatum*, *Persea americana* and *Dacryodes edulis*, *Jordan Journal of Chemistry*, **2017**, 12(2):113-125.
15. Puscas, A., Tanislav, A.E., Marc, R.A., Muresan, V., Muresan, A.E., Pall, E., Cerbu, C., Cytotoxicity Evaluation and Antioxidant Activity of a Novel Drink Based on Roasted Avocado Seed Powder, Plants, **2022**, 11, 1083. https://doi.org/10.3390/plants11081083
16. Flores, M., Ortiz-Viedma, J., Curaqueo, A., Rodriguez, A., Dovale-Rosabal, G., Magana, F., Vega, C., Toro, M., López, L., Ferreyra, R., Preliminary Studies of Chemical and Physical Properties of Two Varieties of Avocado Seeds Grown in Chile, J. Food Qual. **2019**, 3563750.
17. Egbuonu, A.C., Opara, I.C., Onyeabo, C., Uchenna, N.O., Proximate, functional, antinutrient and antimicrobial properties of avocado pear (*Persea americana*) Seeds, *J Nutr Health Food Eng.*, **2018**, 8(1): 00260. DOI: 10.15406/jnhfe.
18. Ifesan, B.O.T., Olorunsola, B.O., Ifesan, B.T., Nutritional composition and acceptability of candy from avocado seed (*Persea americana), International Journal of Agriculture Innovations and Research*, **2015**, 3(6), 2319-1473
19. Siol, M. and Sadowska, A., Chemical Composition, Physicochemical and Bioactive Properties of Avocado (*Persea americana*) Seed and Its Potential Use in Functional Food Design. *Agriculture* **2023**, 13, 316. https://doi.org/10.3390/agriculture13020316.
20. Nascimento, A.P.S., Duarte, M.E.M., Rocha, A.P.T., Barros, A.N., Valorization of Avocado (*Persea americana*) Peel and Seed: Functional Potential for Food and Health Applications.

Antioxidants, **2025**, 14, 1032. https://doi.org/ 10.3390/ antiox14091032

21. Tremocoldi, M.A., Rosalen, P.L., Franchinm M., Massarioli, A.P., Denny, C., Daiuto. E.R., Paschoal, J.A.R., Melo, P.S., Alencar, S.M., Exploration of avocado by-products as natural sources of bioactive compounds, **2018** PLoS ONE, **2018**, 13(2): e0192577.

22. Kosińska, A., Karamac, M., Estrella, I., Hernández, T., Bartolomé, B., Dykes, G.A., Phenolic compound profiles and antioxidant capacity of *Persea americana* Mill. peels and seeds of two varieties, *Journal of agricultural and food chemistry*, **2012**, 60(18), 4613-4619.

23. Oke, M.A., Adebayo, E.A., Ajisope N.A., Olowe, B.M. and Fasuan, O.S., Avocado (*Persea americana*) peel: a promising source of bioactive compounds. *Front. Nutr.*, 2025, 12: 1642969. doi: 10.3389/fnut.2025.1642969

24. AOAC. Official Methods of Analysis, Association of Official Analytical Chemist. EUA; 2000

25. Velciov, A. B., Riviş, A., Popescu, G. S., Cozma, A., Stoin, D., Petcov, A., Anghel, I–M., Rada, M., Hădărugă, N. G., Preliminary research on the obtaining and nutritional characterization of apple peel powder, *Journal of Agroalimentary Processes and Technologies*, **2022**, 28(4), 375-380;

26. Negrea, M., Cocan, I., Jianu, C., Alexa, E., Berbecea, A., Poiana, M.-A., Silivasan, M., Valorization of Citrus Peel Byproducts: A Sustainable Approach to Nutrient-Rich Jam Production *Foods*, **2025**, 14(8), 1339.

27. Mahawan, M.A., Tenorio, M.F.N., Gomez, J.A., Bronce, R.A., Characterization of flour from avocado seed kernel, *Asia Pacific Journal of Multidisciplinary Research*, **2015**, 3(4), 34-40.

28. Vinha, A., Moreira, J., Barreira, S., Physicochemical Parameters, Phytochemical Composition and Antioxidant Activity of the Algarvian Avocado (*Persea americana* Mill.). *J. Agric. Sci.*, **2013**, 5(12).

29. Wanjiru, S.N., Opiyo, S.A., Njoroge, P.W., Mugendi, B.J., Elemental Composition of Pulp and Seed of Avocado Cultivars From Murang'a County, *IOSR Journal of Applied Chemistry (IOSR-JAC)*, **2025,** 18(1), Sere 1, 2278-5736, 13-20.

30. Arukwe, U., Amadi, B.A., Duru M.K.C., Agomuo, E.N., Adindu, E., Chemical composition of *Persea americana* leaf, fruit and seed, *IJRRAS*, **2012,** 11(2).

31. Tesfaye, T., Ayele, M., Ferede, E., Gibril, M., Kong, F., Sithole, B., A techno-economic feasibility of a process for extraction of starch from waste avocado seeds, *Clean Technologies and Environmental Policy*, **2021,** 23(2), 581-595.

32. Pires, J.B., Dos Santos, F.N., da Cruz, E.P., Fonseca, L.M., Siebeneichler, T.J., Lemos, G.S., Gandra, E.A., Zavareze, E.D.R., Dias, A.R.G., Starch Extraction from Avocado By-Product and Its Use for Encapsulation of Ginger Essential Oil by Electrospinning, *Int. J. Biol. Macromol.*, **2024**, 254, 127617.