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LIPID COMPOSITION AND POTENTIAL HEALTH BENEFITS OF JACKFRUIT (*ARTOCARPUS HETEROPHYLLUS*) PULP AND SEED

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Abstract
Jackfruit (Artocarpus heterophyllus) is widely cultivated in tropical regions and serves as an important food resource, yet its lipid composition remains relatively underexplored. This study comparatively investigated the fatty acid, phospholipid and phytosterol profiles of Artocarpus heterophyllus pulp and seed oils to evaluate their potential nutritional and health benefits Oil extraction was carried out using Soxhlet extraction with n-hexane, while fatty acids were analyzed as methyl esters using gas chromatography. Phospholipid and phytosterol compositions were determined using standard chromatographic and spectrophotometric methods. The results showed that the seed oil contained a higher total fatty acid content than the pulp oil. Linoleic acid (36.18%) was the predominant fatty acid in the pulp, while myristic (70.70%) dominated the seed oil. The total saturated fatty acids (TSFA) were 25.44% and 79.35%, whereas total unsaturated fatty acids (TUFA) were 74.49% and 21.83% in the pulp and seed, respectively. The pulp exhibited a higher total essential fatty acids (TEFAs) content and a more favourable PUFA/SFA ratio, indicating greater cardiovascular health potential. Phosphatidylcholine was the abundant phospholipid in both samples, with concentrations of 53.80 mg/100 g (pulp) and 46.80 mg/100 g (seed). Phytosterol analysis revealed β-sitosterol as the dominant sterol, with higher total phytosterol content observed in the seed. The presence of these bioactive lipid components suggests that jackfruit pulp and seed possess significant nutritional and functional potential. The pulp oil, in particular may serve as a valuable source of heart-healthy unsaturated fatty acids, while the seed oil may have potential applications in functional foods and nutraceutical formulations due to its phytosterol content. These findings highlight the importance of promoting the utilization of jackfruit as a sustainable food resource with potential health benefits. However, phosphatidylserine levels in both samples were below the recommended USFDA standard.
Keywords: *Jackfruit; phospholipids; phytosterols; Pulp; seed*

Introduction

There is a growing global interest in plant-based foods due to their nutritional, therapeutic, and environmental benefits. Plant-derived foods such as fruits, vegetables, legumes, nuts, and seeds provide essential nutrients including carbohydrates, proteins, dietary fiber, vitamins, minerals, fats and oils that are necessary for human health. Diets rich in plant-based foods have been associated with a reduced risk of chronic diseases such as obesity, diabetes mellitus, hypertension, and cardiovascular disorders (Maki *et al*., 2021; Naghavi *et al.*, 2013; Calas *et al*., 2017).

Despite the nutritional abundance of plant resources, many developing countries continue to experience food insecurity. According to the Global Report on Food Crises, approximately 282 million people across 59 countries experienced acute food insecurity in 2023, with projections indicating a further increase (FSIN & Global Network against Food Crises, 2024). Addressing this challenge requires increased utilization, cultivation, and value addition of underexploited plant food resources that are locally available and nutritionally beneficial.

Jackfruit (*Artocarpus heterophyllus)*, a member of the family Moraceae, is a tropical tree fruit native to Southwest India and widely cultivated across tropical regions of Asia,

Africa, and South America (Ranasinghe *et al.,* 2019). The fruit is valued for its edible pulp and seeds, which are consumed in various forms and utilized in traditional medicine (Brahma & Ray, 2023). Jackfruit pulp and seed are used for cooking, frying, baking, and food formulation due to their mild flavor and functional properties (Deore *et al.,* 2020). In addition, jackfruit oil has attracted interest in the cosmetic and pharmaceutical industries because of its antioxidant potential and suitability for skincare applications (Rahim *et al*., 2023; Afotey *et al*., 2024)).

The nutritional quality of edible oils is largely determined by their fatty acid profile and the presence of bioactive lipid components such as phospholipids and phytosterols (Maki *et al*., 2021). Fatty acids such as linoleic and oleic acids contribute to cardiovascular health, while phospholipids including phosphatidylcholine, phosphatidylinositol, and phosphatidylethanolamine play vital roles in liver function, insulin signaling, and neurological development (Jackson *et al.,* 2024). Phytosterols are well known for their cholesterol-lowering effects and protective roles against cardiovascular diseases (Omachi *et al.,* 2024).

In Nigeria, jackfruit is increasingly underutilized and often regarded as a food for low-income populations, leading to a decline in its cultivation and consumption. Scientific evaluation of its nutritional and health benefits is therefore essential to promote its wider acceptance and utilization. This study aims to evaluate comparatively the fatty acid, phospholipid, and phytosterol compositions of jackfruit pulp and seed oils and to assess their potential health benefits, with a view to encouraging increased consumption and value addition of this underexploited tropical fruit.

Materials and Methods

Sample collection and treatment

Fresh jackfruit (*Artocarpus heterophullus*) was purchased from Eke Awka Market, Awka South Local Government Area, Anambra State, Nigeria. The fruit was cut open longitudinally using a clean stainless-steel knife to separate the pulp from the seeds. The pulp was carefully scraped using a stainless-steel spoon, while the seeds were manually removed and thoroughly washed under running tap water to remove adhering materials. The pulp and seed samples were placed separately on clean trays and sun-dried to constant weight. The dried samples were then crushed using a pestle and mortar, further ground with an electric grinder, sieved to obtain uniform particle sizes, and stored in airtight containers prior to laboratory analysis.

Oil Extraction

Oil extraction was carried out using the Soxhlet extraction method. Approximately 200 g of the ground pulp and seed samples were wrapped in filter paper and placed separately into extraction thimbles. Each thimble was inserted into a Soxhlet extractor, and 500 mL of analytical-grade n-hexane was used as the extraction solvent. The extraction was allowed to proceed for about 6 h under continuous reflux. After extraction, the solvent was recovered and reused, while residual hexane in the oil was removed by distillation. The extracted oil was weighed, recorded, and stored in labeled airtight containers at room temperature until further analysis.

Fatty Acid Determination

Fatty acid composition of the extracted oils was determined by converting the oils to fatty acid methyl esters (FAMEs) following the method described by the Association of Official Analytical Chemists (AOAC, 2010). Exactly 0.1 g of each oil sample was weighed into a 40 mL glass vial and mixed with 5 mL of 0.50 M methanolic sodium hydroxide (NaOH). The mixture was heated at 60 ℃ for 3 min and allowed to cool to room temperature. Subsequently, 6 mL of 14% boron trifluoride (BF_3) solution was added, and the mixture was reheated at 60 ℃ for another 3 min. After cooling, 10 mL of isooctane was added, shaken thoroughly, and allowed to settle. The upper organic layer was collected and passed through anhydrous sodium sulphate to remove residual moisture. Gas chromatographic analysis was performed using a HP 6890N gas chromatograph equipped with a flame ionization detector (FID) and fitted with an HP-88 capillary column (100 m x 0.2 mm x 0.2 µm). Injector and detector temperatures were set at 240 ℃ and 250 ℃, respectively. The oven temperature was initially held at 160 ℃ for 2 min, increased to 185 ℃ at a rate of 4 ℃/min, and then raised to 200 ℃ at a rate of 1 ℃/min and held for 46.75 min, giving a total run time of 70 min. Helium was used as the carrier gas at a flow rate of 1 mL/min. Fatty acids were identified by comparing the relative retention times of sample peaks with those of standard Supelco 37 FAME mixtures. Results were expressed as relative percentages of the total fatty acid composition, and each analysis was carried out in triplicate.

Phospholipid Determination

Phospholipid extraction was carried out using the Folch method as described by Christie (2018). One hundred grams (100 g) of each sample were subjected to total lipid extraction. Polar lipids were isolated from the total lipids using column chromatography. Each sample was applied to a 40 × 2 cm glass column packed with silica gel and (Unisil, 100–200 mesh; Clarkson Chemicals Co., USA) and eluted sequentially with chloroform. Phospholipid classes were separated using a modified two-dimensional thin-layer chromatography (TLC) technique on 20 × 20 cm glass plates precoated with a 0.2 mm silica gel 60 G (Merck) impregnated with aqueous ammonium sulphate solution (1 g/100 mL). Individual phospholipids were detected by spraying with specific reagents and identified by comparing their respective retention *Rf* values with those of authentic commercial standards analyzed under identical conditions. Quantification was performed spectrophotometrically by measuring phosphorus content at 700 nm after scraping the phospholipid spots and mineralizing them using a perchloric acid-sulphuric acid mixture (1:1, v/v). A calibration curve was prepared using potassium dihydrogen phosphate (KH_2PO_4) as the standard, which showed linearity over the concentration range of 1–130 µg/mL.

Phytosterol Determination

Phytosterol analysis was conducted according to the AOAC (2010) method. Fifty milligrams (50 mg) of each oil sample were weighed into sealable tubes, and 200 µL of internal standard solution was added. Alkaline hydrolysis was performed by adding 5 mL of 2 M potassium hydroxide (KOH) in ethanol, followed by shaking and heated at 75 ℃ for 30 min. After saponification, the mixture was cooled to room temperature, and 2 mL of distilled water and 5 mL of hexane were added. The mixture was shaken thoroughly to extract unsaponifiable matter. Extraction was repeated three times with hexane, and the combined hexane extracts were evaporated under a stream of nitrogen. The residue was

derivatized by adding 10 µL of N-methyl-N-trimethylsilylheptafluorobutyramide-1-methylimidazole (95:5 v/v), sealed, and heated at 75 °C for 20 min. After cooling, hexane was added to make up the volume to 1 mL prior to GC–MS analysis.

Statistical Analysis

All analyses were performed in triplicate. Data were expressed as percentages, mean values, standard deviation (SD), and coefficient of variation (CV).

Results

Table 1: Fatty acid composition of *Artocarpus heterophyllus* pulp and seeds

Fatty Acid (%)	Pulp	Seed	Mean	SD	CV (%)
Caprylic acid (C8:0)	0.00	0.08	0.04	0.06	150.00
Capric acid (C10:0)	5.00	0.61	2.81	3.11	110.68
Lauric acid (C12:0)	0.00	3.37	1.69	2.38	140.83
Palmitic acid (C16:0)	3.75	1.78	2.77	1.39	50.18
Myristic acid (C14:0)	12.70	70.70	41.70	41.01	98.35
Palmitoleic acid (C16:1)	0.16	1.18	0.67	0.72	107.46
Stearic acid (C18:0)	2.11	2.44	2.28	0.23	10.09
Oleic acid (C18:1)	27.15	16.50	21.39	8.15	38.10
Linoleic acid (C18:2)	36.18	2.59	19.39	23.74	122.43
Alpha linolenic acid (C18:3)	0.73	0.88	0.81	0.10	12.35
Arachidic acid (C20:0)	0.83	0.37	0.60	0.33	55.00
9-Eicosenoic acid (C20:1)	10.27	0.64	5.44	6.83	125.55
Arachidonic acid (C20:4)	0.00	0.07	0.04	0.05	125.00
Lignoceric acid (24:0)	1.05	0.00	0.53	0.75	141.51

Values are presented as means ± standard deviation (n = 3). SD is standard deviation while CV is coefficient of variation

Table 2: Quality parameters of *Artocarpus heterophyllus* pulp and seeds

Parameters	Pulp	Seed	Mean	SD	CV (%)
TSFA	25.44	79.35	52.40	5.10	10.11
TUFA	74.49	21.83	48.16	4.75	9.70
TMUFA	37.58	18.29	27.94	0.72	2.53
TDUFA	36.18	2.59	19.39	23.74	122.43
TPUFA	0.73	0.95	0.84	0.09	12.25
TEFA	36.91	3.47	20.02	0.70	3.4
O/L	0.75	6.37	3.56	2.81	78.93

TSFA = Total saturated fatty acid; TUFA = Total unsaturated fatty acid; TMUFA = Total monounsaturated fatty acid; TDUFA = Total Di unsaturated fatty acid; TPUFA = Total polyunsaturated fatty acid; TEFA = Total essential fatty acid; O/L = Oleic/Linoleic acid ratio

Table 3: Phospholipid composition of Artocarpus heterophyllus pulp and seeds

Phospholipids (mg/100 g)	Pulp	Seed	Mean	SD	CV (%)
Phosphatidylcholine (PC)	53.80	46.80	50.30	4.95	9.80
Phosphatidylinositol (PI)	27.88	29.00	28.44	0.79	2.80
Phosphatidylethanolamine (PE)	14.77	16.44	15.63	1.17	7.50
Phosphatidic acids (Pas)	0.70	0.50	0.60	0.04	6.70
Phosphatidylserine (PS)	0.53	0.20	0.37	0.24	64.90
Lysophosphatidylcholine (LPC)	0.72	ND	0.36	0.51	141.70
Diphosphatidylglycerol (DPG)	ND	3.96	1.98	2.80	141.40
Sphingomyelin (SM)	2.40	3.10	2.75	0.49	17.80

Table 4: Phytosterol composition of *Artocarpus heterophyllus* pulp and seeds

Phytosterol (mg/100 g)	Pulp	Seed	Mean	SD	CV (%)
Ergosterol	2.54	1.56	2.05	0.69	33.70
Campesterol	25.10	90.30	57.70	46.10	79.90
Campestanol	4.95	2.87	3.91	1.47	37.60
Stigmasterol	22.18	21.13	21.66	0.75	3.50
β-Sitosterol	166.0	157.80	161.90	5.80	3.60
5-Avenasterol	19.00	29.73	24.37	7.59	39.00
Cycloartenol	1.81	0.75	1.28	0.75	58.60
Cycloartenol	17.75	24.23	21.00	4.60	21.90
24-Methylenecycloartanol	4.37	4.96	4.67	0.42	9.00

Discussion

The fatty acid composition results of *Artocarpus heterophyllus* pulp and seed oils are presented in Table 1. Linoleic acid (C18:2) was the predominant fatty acid in the pulp oil, accounting for 36.18% of the total fatty acids, followed by oleic acid (C18:1n9) at 27.15%. Other notable fatty acids in the pulp included myristic acid (12.70%) and 9-eicosenoic acid (10.27%). Minor components such as palmitoleic acid, arachidic acid, and lignoceric acid were present in relatively low proportions, while caprylic and arachidonic acids were not detected in the pulp oil. In contrast, myristic acid (C14:0) dominated the seed oil, constituting 70.70% of the total fatty acid content. This was followed by oleic acid (15.63%), lauric acid (3.37%, and linoleic acid (2.59%). The presence of caprylic, palmitoleic, and arachidonic acids in the seed oil was minimal. The value of linoleic acid found in the pulp was higher than that found in *persea americana* pulp (25.02 %), strawberry (1.3 %) and *Cochorus olitorius* (22.29 %) as reported by Aremu *et al.* (2020), Bajramova and Spegel, (2022) and Usman *et al.* (2024), respectively. The fatty acid composition of jackfruit pulp and seed oils revealed distinct differences in lipid quality and potential health implications.

The predominance of linoleic acid in the pulp oil highlights its nutritional significance, as linoleic acid is an essential di-unsaturated fatty acid required for normal physiological functions and cardiovascular health. Diets rich in linoleic acid have been associated with reduced plasma cholesterol levels and a lower risk of coronary heart disease (Mazidi *et al*., 2022; Shen *et al*., 2023). In contrast, the seed oil was characterized by an exceptionally high level of myristic acid, a saturated fatty acid known to influence serum lipid profiles by increasing low-density lipoprotein (LDL) cholesterol when consumed in excess. The high saturated fatty acid content of the seed oil suggest that, although it may possess functional and industrial applications, its direct dietary consumption should be moderated compared to the pulp oil. The higher proportion of oleic acid observed in the pulp oil further enhances its nutritional value. Oleic acid, a monounsaturated fatty acid, is well documented for its beneficial effects on lipid metabolism, oxidative stability, and cardiovascular health (Wang *et al*., 2025). Similar fatty acids patterns dominated by linoleic and oleic acids have been reported in commonly consumed plant oils such as soybean, peanut, and lentil oils, supporting the nutritional relevance of jackfruit pulp oil as a plant-based lipid source (Tian *et al*., 2023).

The lipid quality parameters of jackfruit pulp and seed oils are summarized in Table 2. The total saturated fatty acid (TSFA) content was significantly lower in the pulp oil (25.44%) compared to the seed oil (79.35%). Conversely, the total unsaturated fatty acids (TUFA) were higher in the pulp (74.49%) than in the seed (21.83%). The total monounsaturated fatty acids (TMUFA) were 37.58% in the pulp and 18.29% in the seed, while total di-unsaturated fatty acids (TDUFA) were markedly higher in the pulp (36.18%) than in the seed (2.59%). Although the total polyunsaturated fatty acid (TPUFA) contents of both samples were low, the pulp oil exhibited a slightly higher PUFA/SFA ratio (0.03) compared to the seed oil (0.01). The total

essential fatty acid (TEFA) content was substantially higher in the pulp oil (37.01%) than in the seed oil (3.03%). Additionally, the oleic/linoleic (O/L) ratio was lower in the pulp oil (0.75) compared to the seed oil (6.37), reflecting differences in oxidative stability and nutritional quality.

Lipid quality indices provide valuable insight into the health implications of dietary fats (Ulbricht & Southgate, 2021; FAO, 2023). The markedly lower TSFA content and higher TUFA content observed in the pulp oil indicate a more favourable lipid profile compared to the seed oil. High TUFA and low TSFA levels are associated with improved lipid metabolism and reduced risk of cardiovascular disease (Jackson *et al.,* 2024). The pulp oil also exhibited higher total essential fatty acids (TEFA) and a more favourable PUFA/SFA ratios of both samples were relatively low, the pulp oil demonstrated a superior balance, suggesting a better capacity to support cardiovascular health (FAO, 2023). Furthermore, the lower oleic/linoleic (O/L) ratio in the pulp oil reflects its higher linoleic acid content, which is nutritionally advantageous but may reduce oxidative stability during storage and processing (Choe & Min, 2020; Shahidi & Ambigaipalan, 2023).

The phospholipid composition of *Artacarpus heterophyllus* pulp and seed are presented in Table 3. Phosphatiy lcholine (PC) was the most abundant phospholipid in both samples, with concentrations of 53.80 mg/100 g in the pulp and 46.80 mg/100 g in the seed. This was followed by phosphatidylinositol (PI), which recorded values of 27.88 mg/100 g in the pulp and 29.00 mg/100 g in the seed. Phosphatidylethanolamine (PE) was also present in appreciable amounts, with concentrations of 14.77 mg/100 g and 16.44 mg/100 g in the pulp and seed, respectively. Phosphatidylserine levels were particularly low in both samples, with values of 0.53 mg/100 g in the pulp and 0.20 mg/100 g in the seed.

Phospholipids play critical roles in membrane structure, lipid transport, and cellular signaling (Vance & Tasseva, 2023; Ridgway, 2022). The dominance of PC in both pulp and seed samples is nutritionally important, as PC is a major structural component of cell membranes and is involved in lipid metabolism and liver function (Li *et al*., 2021; Vance, 2022). Adequate dietary intake of phosphatidylcholine has been linked to improved liver health and reduced risk of metabolic disorders (Zeisel & Costa, 2023). PI and PE, which were present in appreciable quantities in both samples, are involved in insulin signaling, neuronal development, and membrane integrity (Casares *et al.,* 2022; Vance & Tasseva, 2023). The relatively higher levels of these phospholipids in jackfruit pulp and seed underscore beyond basic nutrition. However, PS levels in both samples were notably low and below recommended dietary levels, indicating that jackfruit oils may not serve as significant dietary sources of this particular phospholipid (Kim *et al.,* 2020; Glade & Smith, 2021).

The phytosterols profiles of jackfruit pulp and seed oils are shown in Table 4. β-Sitosterol was the predominant phytosterol in both samples, accounting for 166.00 mg/100 g in the pulp and 157.80 mg/100 g in the seed. Other notable phytosterols included campesterol, stigmasterol, 5-avenasterol, campestanol, cycloartenol, and 24-methylenecycloartanol. Campesterol content was considerably higher in the seed oil (90.30 mg/100 g) compared to the pulp (25.10 mg/100 g), whereas the pulp oil showed slightly higher levels of stigmasterol.

Phytosterols are well recognized for their ability to reduce intestinal absorption of cholesterol, thereby lowering serum total and LDL cholesterol levels (Ras *et al*., 2020). The predominance of β-sitosterol in both jackfruit pulp and seed oils aligns with previous studies on plant-derived oils and reinforces their potential cardio-protective properties (Shahidi & Ambigaipalan, 2023). The higher total phytosterol content observed in the seed oil suggests a greater

cholesterol-lowering capacity compared to the pulp oil. The presence of other sterols such as campesterol, stigmasterol, and 5-avenasterol further enhances the functional value of jackfruit oils because these phytosterols contribute collectively to cholesterol-reducing and anti-inflammatory effects (Racette *et al.*, 2022; Rocha *et al*., 2021). These findings support the potential use of jackfruit seed oil as a functional ingredient in food formulations and nutraceutical applications, despite its high saturated fatty acid content (Shahidi & Ambigaipalan, 2023).

Conclusion

This study evaluated the lipid composition of jackfruit (*Artocarpus heterophyllus*) pulp and seed with particular emphasis on their fatty acid, phospholipids, and phytosterol profiles. The results revealed notable differences between the two samples interms of lipid quality and potential health implications. The pulp oil was characterized by a higher proportion of unsaturated fatty acids, particularly linoleic and oleic acid, which are widely recognized for their beneficial effects on cardiovascular health and lipid metabolism. In contrast, the seed oil contained a higher proportion of saturated fatty acids, with myristic acid being the dominant component. Despite this, the seed oil exhibited a higher total phytosterol content, which is associated with cholesterol-lowering properties and potential cardio-protective effects. Phospholipid analysis indicated that phosphatidylcholine, phosphatidylinositol, and phosphatidylethanolamine were the major phospholipid fractions present in both the pulp and seed. These compounds play important physiological roles in membrane structure, liver transport, and cellular signaling processes.

Overall, the findings demonstrate that jackfruit pulp and seed contain bioactive lipid components with significant nutritional and functional potential. The pulp oil, due to its higher unsaturated fatty acid content, may serve as a healthier dietary lipid source, while the seed may have promising applications in functional food formulations and nutraceutical products due to its phytosterol richness.

Recommendations

Based on the findings of this study, the following recommendations are proposed:

- **Increased utilization of Jackfruit**: Greater attention should be given to the utilization of jackfruit pulp and seed as valuable sources of nutritionally beneficial lipids, particularly in regions where the fruit is underutilized.
- **Food and Nutraceutical Applications**: The lipid fractions obtained from jackfruit pulp and seed could be explored for incorporation into functional foods, dietary supplements, and nutraceutical products due to their bioactive components.
- **Further Research**: Additional studies should be investigate the antioxidant properties, stability, and bioavailability of the identified lipid compounds to better understand their health-promoting potentials
- **Processing and Industrial Development**: Research into improved processing techniques and oil extraction methods is recommended to enhance yield and maintain the nutritional quality of jackfruit-derived lipids.
- **Public Awareness and Agricultural Promotion**: Efforts should be made to promote the cultivation and consumption of jackfruit as a nutrient-rich fruit that can contribute to dietary diversification and food security.

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