JOBIMB, 2025, Vol 13, No 2, 46-50
https://doi.org/10.54987/jobimb.v13i2.1135

JOURNAL OF BIOCHEMISTRY, MICROBIOLOGY AND BIOTECHNOLOGY
Website: http://journal.hibiscuspublisher.com/index.php/JOBIMB/index
JOBIMB VOL 13 NO 2 2025
AI and Biochemistry

# Proximate Composition, Phenolic Content, and Antioxidant Activity of the pulp and pericarp of Takob Akob Fruit (*Garcinia parvifolia*)

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**History**

Received: 12th May 2025
Received in revised form: 24th July 2025
Accepted: 19th Aug 2025

**Keywords**

*Garcinia parvifolia*
Antioxidants
Phytochemical content
Pulp
Pericarp

**SDG Keywords**

SDG 2 Zero Hunger
SDG 3 Good Health and Well-being
SDG 12 Responsible Consumption and Production

**Abstract**

Takob Akob (*Garcinia parvifolia*) is a lesser-explored indigenous fruit from Sabah, Malaysia, known for its sour taste, which limits its use in daily nutrition and commercialization. This study aims to determine the proximate composition, phytochemical content, and antioxidant activity of the fruit to enhance knowledge of its nutritional benefits. The pulp and pericarp were analysed using AOAC 2000 methods, while phytochemical content and antioxidant activity were assessed using a spectrophotometer. Results showed that the pulp had higher fat (12.61±0.16%) and protein (4.14±0.12%) content than the pericarp (fat: 8.78±0.47%, protein: 2.67±0.04%). However, carbohydrate content was greater in the pericarp (41.80±0.43%) than in the pulp (37.19±0.49%). Phytochemical analysis revealed higher phenolic (0.22±0.01 mg GAE/g), flavonoid (1.32±0.02 mg QE/g), and antioxidant activity in the pulp compared to the pericarp, whereas carotenoid content was higher in the pericarp (58.35±0.33 µg/g) than in the pulp (22.85±0.34 µg/g). Antioxidant activity, measured using DPPH and ABTS methods, was also greater in the pulp. These findings suggest that the pulp of Takob Akob contains higher micronutrients, phytochemicals, and antioxidant activity than the pericarp, making it a potential functional food ingredient. Further research is needed to optimize its antioxidant properties through improved storage or formulation with other antioxidant-rich ingredients.

## INTRODUCTION

Sabah, Malaysia, is rich in biodiversity and home to over 200 species of native edible fruits, many of which remain underutilized despite their potential health benefits. One such fruit is *Garcinia parvifolia*, locally known as Takob Akob, which is traditionally used as a sour seasoning and food preservative [1]. While its dried skin is commonly utilized as sour flakes, the rest of the fruit is often discarded due to its intense sourness, leading to significant food waste. Moreover, the limited scientific research on its nutritional composition and bioactive compounds has restricted its commercial potential. Recent studies, however, have begun to shed light on the bioactive properties of *Garcinia parvifolia*. For instance, previous research has reported that extracts from the fruit exhibit significant antioxidant activity, particularly through free radical scavenging mechanisms such as DPPH and FRAP assays. One study highlighted that both the peel and pulp contain appreciable levels of phenolic compounds and flavonoids, which are primarily responsible for their antioxidant potential. Additionally, the fruit has been found to contain high levels of ascorbic acid and carotenoids, further contributing to its antioxidant capacity. These findings suggest that *Garcinia parvifolia* holds promise as a natural source of antioxidants with potential applications in functional foods and nutraceuticals.

Understanding the nutritional and functional properties of *Garcinia parvifolia* is essential for promoting its utilization beyond traditional applications. This study is significant as it explores the fruit's proximate composition, phytochemical content, and antioxidant activity, which could contribute to its incorporation into the food, health, and pharmaceutical industries. Previous studies have reported that *Garcinia*

*parvifolia* contains high levels of total phenolics, flavonoids, and ascorbic acid, all of which are associated with strong antioxidant properties [2, 3]. Additionally, this research supports sustainable food resource management by minimizing waste and creating economic opportunities for local communities through value-added product development.

The primary objective of this study is to evaluate the nutritional and bioactive properties of *Garcinia parvifolia*, focusing on its pulp and pericarp, specifically by measuring its total phenolic content, total flavonoid content, carotenoid and ascorbic acid levels, as well as its antioxidant activity. Specifically, the study aims to determine the proximate composition; total phenolic and flavonoid contents; carotenoid and ascorbic acid levels; and antioxidant activity using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) radical scavenging assay methods. The findings will provide scientific insights that can help unlock the potential of this indigenous fruit for broader applications in food and health industries.

## MATERIALS AND METHODS

### Sample preparation

Takob Akob (*Garcinia parvifolia*) fruit was obtained from Menggatal, Sabah during its ripening season. The fruit sample was cleaned, weighed, and separated into pulp and pericarp. The sample was then cut into small pieces at least 1-2 cm and was dried using freeze-drying. The dried pulp and pericarp samples were ground using an electronic blender and seized to make a fine, uniform-sized powder. The sample was stored in an airtight container and stored in a refrigerator (-20°C) until further analysis.

### Proximate Composition Analysis

The fine powders of *Garcinia parvifolia* pulp and pericarp were subjected to proximate composition analysis to determine moisture, ash, protein, fat, crude fiber, and carbohydrate contents. Analyses were carried out following standard procedures described by the Association of Official Analytical Chemists (AOAC, 2000) [4], with minor modifications as specified below. All measurements were performed in triplicate (n = 3) for each sample to ensure accuracy and reproducibility. The instruments used are identified by brand name and country.

### Moisture Content

Moisture content was determined using the oven-drying method (AOAC 925.10). A 2 g sample was placed in a pre-weighed crucible and dried in a Memmert UN110 oven (Memmert GmbH, Germany) at 103 ± 2 °C for 16 hours. The crucible was then cooled in a desiccator and reweighed. Moisture content was expressed as a percentage of the initial weight. Analysis was performed in triplicate.

### Ash Content

Ash content was measured using the dry ashing method (AOAC 923.03). Approximately 2 g of the sample was placed in a pre-weighed porcelain crucible and first charred over a Bunsen burner until no visible smoke remained. The crucible was then transferred to a Nabertherm LHT 02/17 LB muffle furnace (Nabertherm GmbH, Germany) and ashed at 550 °C for 12 hours. After cooling in a desiccator, the final weight was recorded. The ash content was calculated as a percentage of the sample's initial weight. Each measurement was repeated three times.

### Fat Content

Fat content was determined by Soxhlet extraction (AOAC 920.39) using a Foss Soxtec™ 2050 Extraction Unit (Foss, Denmark). Two grams of sample were placed in a thimble and extracted using petroleum ether as the solvent for 1.5 hours. The solvent was removed by evaporation, and the residue was weighed. The fat content was expressed as a percentage of the initial sample weight. Analyses were conducted in triplicate.

### Protein Content

Protein content was estimated using the Kjeldahl method (AOAC 979.09) with a Foss Kjeltec™ 2300 Analyzer Unit (Foss, Denmark). One gram of sample was digested with concentrated sulfuric acid and a catalyst mixture, followed by distillation and titration to determine the nitrogen content. A conversion factor of 6.25 was used to convert nitrogen to crude protein. All measurements were done in triplicate.

### Carbohydrate Content

Carbohydrate content was calculated by difference using the formula:

Carbohydrate (%) = 100 – (Moisture + Protein + Fat + Ash + Crude Fiber)

Each value used in the calculation was the mean of three replicate determinations.

### Crude Fiber Content

Crude fiber content was determined using the Fibretherm system (Gerhardt Analytical Systems, Germany) following the manufacturer's protocol based on the AOAC 978.10 method. One gram of defatted sample was placed in a fiber bag with a glass spacer and subjected to sequential acid and alkali digestion. The digested sample was then dried at 130 °C overnight, weighed, and subsequently ashed in a muffle furnace at 550 °C for 4 hours. After cooling in a desiccator, the crude fiber content was calculated based on the weight difference before and after ashing. All measurements were conducted in triplicate (n = 3).

### Extraction of phenolic and flavonoid compound

The fine powder sample of pulp and pericarp was extracted using 80% to determine total phenolic content, total flavonoid content, and antioxidant activity [5]. In brief, a 0.5 g sample was extracted with 10 mL of 80% methanol (ratio of 1:20) for 2 hours at room temperature on an orbital shaker set at 200 rpm. The mixture is then centrifuged at 1400 ×g for 20 minutes, and the supernatant is poured into a 15 mL vial. Supernatants are combined and used for experiments to determine phytochemical content and antioxidant activity.

### Total Phenolic Content

Total phenolic content was determined using the Folin-Ciocalteu method with gallic acid as the reference standard. A 300 µL extract was mixed with diluted Folin-Ciocalteu reagent and incubated for 5 minutes. Then, sodium carbonate solution (60 g/L) was added, and the mixture was left for 90 minutes at room temperature. Absorbance was measured at 725 nm using a spectrophotometer. The results were expressed as milligrams of gallic acid equivalent per gram of dry sample (mg GAE/g).

### Total flavonoid content

Total flavonoid content was determined using a colorimetric method. A 0.5 mL extract was mixed with 2 mL of distilled water and 0.15 mL of 5% sodium nitrite ($NaNO_2$), then left to stand for 5 minutes. Subsequently, 0.15 mL of 10% aluminium chloride hexahydrate ($AlCl_3 \cdot 6H_2O$) was added and allowed to react for 6 minutes. After that, 1 mL of 1 M sodium hydroxide (NaOH) was added, followed by 1.2 mL of distilled water. The mixture was vortexed thoroughly, and the absorbance was measured at 510 nm using a UV-Vis spectrophotometer (Lambda 25, PerkinElmer, USA). A quercetin standard curve was used, and the results were

expressed as milligrams of quercetin equivalent per gram of dry sample (mg QE/g). All analyses were performed in triplicate (n = 3).

**Carotenoid extraction and determination of total carotenoid content**

The total carotenoid content was determined using the previous method [6] with slight modification. In brief, approximately 15 g of the sample was mixed with 3 g of celite and ground. Carotenoids were extracted using acetone, with repeated filtrations under vacuum until the sample became colourless. The extract was then transferred to a separation funnel with petroleum ether, and acetone was removed by adding ultrapure water. This process was repeated multiple times to eliminate residual solvents. The extract was then dried using anhydrous sodium sulphate and diluted with petroleum ether. The carotenoid content was measured at 450 nm, and the total carotenoid concentration was calculated using a standard formula.

**Ascorbic acid extraction and determination of total ascorbic acid content**

Ascorbic acid was extracted from *Garcinia parvifolia* pulp and pericarp using previous study methods [7]. Five grams of powdered sample were dissolved in distilled water and stirred for 30 minutes. The mixture was filtered, and centrifuged at 4,000 rpm for 10 minutes, and the supernatant was collected for analysis. Ascorbic acid content was determined using redox titration with iodine solution, where oxidation of ascorbic acid to dehydroascorbic acid was indicated by a blue-black starch-iodine complex at the endpoint. Results were expressed in milligrams of ascorbic acid per gram of dry sample.

**DPPH Free Radical Scavenging Assay**

The antioxidant activity was evaluated using the DPPH assay, following the previous method [5]. A 300 µL sample (20–100 µg/mL) was mixed with 3.0 mL of 500 µM DPPH in ethanol. The mixture was shaken and incubated in the dark for 30 minutes at room temperature. Absorbance was measured at 517 nm, and the free radical scavenging activity was calculated as a percentage using the formula, Scavenging effect % = [1 - (sample abs/control abs)] × 100. Ascorbic acid was used as a positive control for comparison.

**ABTS Decolorization Assay**

The ABTS assay was conducted based on previous method [5], with slight modifications. ABTS radical cations were generated by reacting 7 mM ABTS with 2.45 mM potassium persulfate and incubating the mixture in the dark for 15 hours. The solution was then diluted with 80% methanol to an absorbance of 0.7 ± 0.2 at 734 nm. A 100 µL test sample or solvent control was added to 1 mL of ABTS solution, stirred for 45 seconds, and absorbance was measured at 734 nm using a microplate reader. A standard curve was constructed using ascorbic acid (0–100 µg/mL) for quantification. The antioxidant capacity for both DPPH and ABTS assays was also expressed as Ascorbic Acid Equivalent Antioxidant Capacity (AEAC, mg AAE/g sample) using a standard calibration curve of ascorbic acid ($R^2 = 0.99$).

**Statistical analysis**

All tests were performed in triplicate, and results were expressed as mean ± standard deviation (n = 3). Statistical analysis was conducted using the t-test in Statistical Package for the Social Sciences (SPSS) version 29.0 (IBM Corp., Armonk, NY, USA), with statistical significance set at $p < 0.05$. The t-test was used to compare the proximate composition, phytochemical content, and antioxidant activity between the pulp and pericarp of *Garcinia parvifolia* fruit.

## RESULT AND DISCUSSION

**Proximate Composition**

From **Table 1**, significant differences ($p < 0.05$) were observed in carbohydrate, fat, and protein contents between the pulp and pericarp of *Garcinia parvifolia*. The pericarp contained a higher carbohydrate content (41.80 ± 0.43%) than the pulp (37.19 ± 0.49%). This difference can be attributed to the pericarp's role as a protective barrier and its involvement in nutrient transport. During fruit ripening, starches are hydrolyzed into soluble sugars, which often accumulate in the skin to enhance its protective functions and structural integrity. Variations in carbohydrate distribution are influenced by species, cultivars, and environmental factors affecting metabolic processes [8].

Conversely, fat and protein contents were higher in the pulp (12.61 ± 0.16% and 4.14 ± 0.12%, respectively) compared to the pericarp (8.78 ± 0.47% and 2.67 ± 0.04%). The pulp acts primarily as a nutrient-rich tissue that attracts seed dispersers such as animals. Elevated fat content increases the pulp's energy density, making it more appealing for consumption, thus aiding seed dispersal. Protein accumulation supports seed development by providing essential nitrogenous compounds necessary for embryo growth [9]. The pericarp's protective role requires fewer nutrient reserves, focusing instead on structural compounds.

**Table 1.** Proximate composition of the pulp and pericarp of *Garcinia parvifolia* using a dry basis. Values are expressed as mean ± standard deviation (n=3). Different superscript letters (a, b) indicate significant differences ($p < 0.05$) within the row.

| Proximate Composition (%) | pulp | pericarp |
|---|---|---|
| Ash | 1.45±0.11$^a$ | 1.93±0.05$^a$ |
| Carbohydrates | 37.19±0.49$^b$ | 41.80±0.43$^a$ |
| Moisture | 15.33±0.58$^a$ | 15.24±0.29$^a$ |
| Fat | 12.61±0.16$^a$ | 8.78±0.47$^b$ |
| Protein | 4.14±0.12$^a$ | 2.67±0.04$^b$ |
| Crude Fiber | 29.35±0.25$^a$ | 29.59±0.09$^a$ |

**Phytochemical Content**

As shown in **Table 2**, the total phenolic and flavonoid contents were significantly higher in the pulp than in the pericarp (0.22 ± 0.01 mg GAE/g vs. 0.13 ± 0.01 mg GAE/g for phenolics and 1.32 ± 0.02 mg QE/g vs. 0.51 ± 0.03 mg QE/g for flavonoids). This suggests that the pulp may provide more substantial antioxidant benefits. Phenolic and flavonoid compounds are typically involved in the plant's defense against oxidative stress and may accumulate more in the metabolically active pulp to protect developing seeds. However, the values in this study were lower compared to Hassan et al. [5], potentially due to differences in extraction methods, fruit maturity, or post-harvest handling and storage which can degrade sensitive phytochemicals.

The significantly higher carotenoid content observed in the pericarp (58.35 ± 0.33 µg/g) compared to the pulp (22.85 ± 0.34 µg/g) can be attributed to the pericarp's role in fruit protection and attraction. Carotenoids are pigments primarily responsible for the bright coloration in fruit skins, which aid in attracting animals for seed dispersal and provide photoprotection against oxidative stress and UV radiation. The pericarp, being the outer protective layer, accumulates more carotenoids to shield the developing seeds from photooxidative damage and contribute to the characteristic fruit colour that signals ripeness. Additionally, environmental factors such as light exposure and the fruit's maturity stage can enhance carotenoid biosynthesis in the pericarp. This protective and signaling function justifies the higher carotenoid accumulation in the pericarp compared to the pulp, which mainly serves as a nutrient storage tissue for seed

development. The ascorbic acid content in the pulp and pericarp of *Garcinia parvifolia* was 1.23 ± 0.35 mg/g and 1.26 ± 0.28 mg/g dry weight, respectively, with no significant difference between the two parts. These values correspond to approximately 123–126 mg/100 g dry weight, which is considered a substantial source of vitamin C. This level is comparable to or slightly higher than that reported for other Garcinia species. For example, *Garcinia mangostana* (mangosteen) has been reported to contain 53–100 mg/100 g fresh weight of ascorbic acid [10,11], while *Garcinia indica* (kokum) shows a range between 80 and 110 mg/100 g [12]. Thus, *G. parvifolia* demonstrates a promising ascorbic acid profile relative to its genus. This antioxidant vitamin plays a crucial role in neutralizing reactive oxygen species and contributes to the fruit's potential as a functional food.

**Table 2.** Phytochemical content of pulp and pericarp of *Garcinia parvifolia* fruit (dry basis). Values are expressed as mean ± standard deviation (n=3). Different superscript letters (a, b) indicate significant differences ($p < 0.05$) within the row.

| Phytochemicals | pulp | pericarp |
|---|---|---|
| Phenolic (mg GAE/g) | 0.22±0.01[a] | 0.13±0.01[b] |
| Flavonoid (mg QE/g) | 1.32±0.02[a] | 0.51±0.03[b] |
| Carotenoid (µg/g) | 22.85±0.34[b] | 58.35±0.33[a] |
| Ascorbic Acid (mg/g) | 1.23±0.35[a] | 1.26±0.28[a] |

**Antioxidant Activity**

The antioxidant potential of *Garcinia parvifolia* pulp and pericarp was evaluated using both DPPH and ABTS radical scavenging assays. In the DPPH Radical Scavenging Activity (**Fig. 1**), ascorbic acid exhibited near-complete inhibition at higher concentrations, consistent with its well-established antioxidant properties. The pulp extract showed a moderate increase in scavenging activity with increasing concentration, whereas the pericarp displayed minimal activity without a clear dose-response pattern. These findings suggest that the antioxidant compounds present in both extracts were not potent enough under the tested conditions to yield significant radical scavenging effects. Consequently, $EC_{50}$ values could not be determined for either extract.

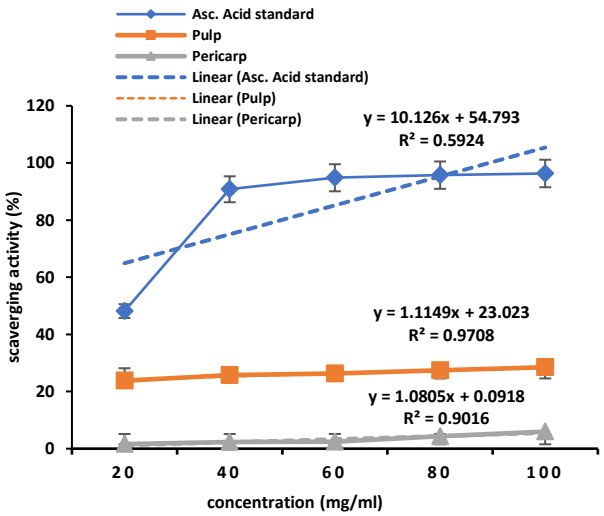


**Fig. 1.** DPPH Radical Scavenging Activity of *Garcinia parvifolia* pulp and pericarp compared to ascorbic acid standard.

The comparatively lower antioxidant activity observed—relative to previous studies such as Hassan et al. [5]—may be attributed to the degradation of antioxidant compounds during storage. This emphasizes the critical role of proper sample preservation and handling in maintaining the integrity of bioactive constituents [13]. The ABTS Radical Cation Decolorization Assay (**Fig. 2**) supported the DPPH findings. Ascorbic acid again showed strong inhibition (>95%) across all concentrations. The pulp extract achieved a maximum inhibition of 35%, while the pericarp reached only 12%. Although a calibration curve for ascorbic acid was established, the low scavenging activity of the extracts rendered AEAC (ascorbic acid equivalent antioxidant capacity) values unreliable. Therefore, ABTS results for pulp and pericarp are expressed only in terms of percentage inhibition.

Despite the inability to express antioxidant activity in mg AAE/g for the ABTS assay, the observed inhibition still confirms the presence of antioxidant compounds in *G. parvifolia*, with higher activity in the pulp than in the pericarp. Variations in antioxidant capacity compared to prior literature may result from differences in extraction methods, plant maturity, or post-harvest handling and storage. Together, these results suggest that *G. parvifolia* pulp and pericarp possess measurable but relatively low antioxidant activity, with the pulp exhibiting higher potential. Future studies employing fresh samples, broader extraction techniques, and additional antioxidant assays may further clarify the functional value of this underutilised fruit.

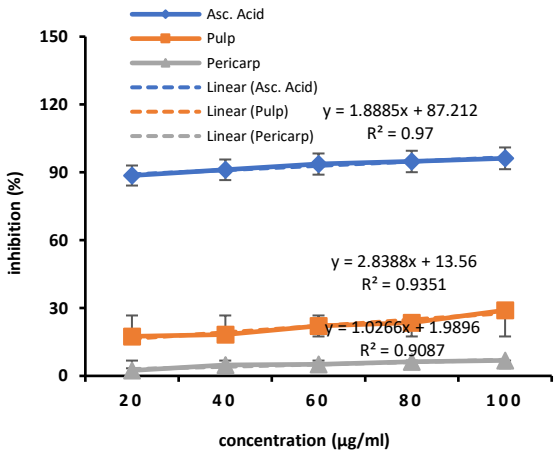


**Fig. 2**. ABTS decolorization assay of *Garcinia parvifolia* pulp and pericarp compared to ascorbic acid standard.

## CONCLUSION

In conclusion, the proximate composition, phenolic and flavonoid contents, and antioxidant activity of the pulp and pericarp of *Takob Akob* (*Garcinia parvifolia*) were evaluated. The pulp exhibited significantly higher levels of fat and protein, greater concentrations of phenolic and flavonoid compounds, and stronger antioxidant activity compared to the pericarp. These findings suggest that the pulp has greater potential for functional food applications. Nonetheless, limitations such as seasonal availability, rapid postharvest deterioration, and quality degradation during frozen storage must be addressed to enhance its commercial viability. Future research should focus on the identification of other bioactive compounds and further investigation into their potential health benefits, particularly for weight management and antioxidant protection.

## CONFLICT OF INTEREST

The authors have declared that no conflict of interest exists.

## ACKNOWLEDGEMENT

I am grateful to God for His blessings throughout my studies and the completion of this project. My sincere appreciation goes to my supervisor, Ts. Dr. Mohd Nazri Abdul Rahman, for his guidance and encouragement. I also extend my gratitude to my parents for their continuous support. Special thanks to Madam Clerice from SMK Tambunan for assisting in sample preparation, and to my friends for their help during sample handling and for their encouragement. I also appreciate the laboratory assistants at the Faculty of Food Science and Nutrition for their support, as well as everyone who contributed to the success of this research project.

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