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Isolation of citric acid-producing *Aspergillus niger* from environmental sources using Corn starch as a substrate

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ABSTRACT

This study focuses on producing citric acid through fermentation using *Aspergillus niger* and corn starch as a substrate. Indigenous *A. niger* strains were isolated from environmental sources, including soil, onion and raw coconut by using Sabouraud's dextrose agar medium. For this isolation and identification, plating, pure culturing, incubating, staining, biochemical inoculating such techniques were used. The mycelia and cytoplasm were stained using Lactophenol and cotton blue. 21 isolates in total were collected, with 3 (NB07, NB15, NB19) displaying morphological characteristics similar to the reference isolate, *A. niger*. All isolates demonstrated the ability to produce citric acid, though their production efficiencies varied based on their respective citric acid production indices. Onion sample NB19 proved to be the most effective sampling source for isolating citric acid-producing *A. niger* strains. Pure cultures of the isolated *A. niger* were inoculated into flasks containing corn starch at various concentrations and incubated at 28°C for a duration of 144 hours to optimize citric acid production. Qualitative and Quantitative analyses were then performed *via* addition of bromocresol green and titration to determine citric acid concentration respectively.

Figures : 04 References : 14 Table : 00

KEY WORDS : *Aspergillus niger*, Citric acid production, Corn starch, Fungal morphology,

Introduction

Citric acid is a water-soluble, specialty organic acid that appears as a white, crystalline powder. known for its significant buffering capacity in aqueous solutions, citric acid plays a key role across various industries. Citric acid is a weak organic acid with the chemical formula $C_6H_8O_7$. known for its role as a natural preservative, it is commonly used to impart a sour or acidic taste to foods and beverages. Biochemically, its conjugate base, citrate, serves as an important intermediate in the citric acid cycle—a fundamental metabolic pathway in aerobic organisms. Structurally, citric acid contains three carboxyl (R-COOH) groups[1], contributing to its acidic properties. In 2023, the global citric acid market was projected to increase to approximately $3.2 billion[5]. Annually, over a million tons of citric acid are produced worldwide, meeting the high demand for this versatile compound[9]. The World Health Organization has designated citric acid as safe for use in foods and other applications[14]. Citric acid has diverse commercial applications, primarily in the food and beverage industries, where it is valued as: Citric acid's tart flavor enhances the taste of food products, offering a clean, acidic profile. It helps to maintain and control the acidity level, improving both flavor and stability in various formulations. Citric acid prevents spoilage by inhibiting the growth of microorganisms, extending the shelf life of many products. It binds to metal ions, preventing them from participating in undesirable chemical reactions, especially in cleaning products. It adds stability and preserves the quality of food, beverages, and other products. In foods, citric acid acts as an acidifier and leaves minimal aftertaste, making it ideal for a variety of culinary applications[5]. In the beverage industry, it enhances the flavor profile and maintains product stability.

The primary substrates for large-scale citric acid fermentation, using submerged fermentation techniques, are beet or cane molasses, corn starch. Several alternative production methods exist, including extraction from citrus fruits and various other biosynthetic processes, making citric acid production versatile and

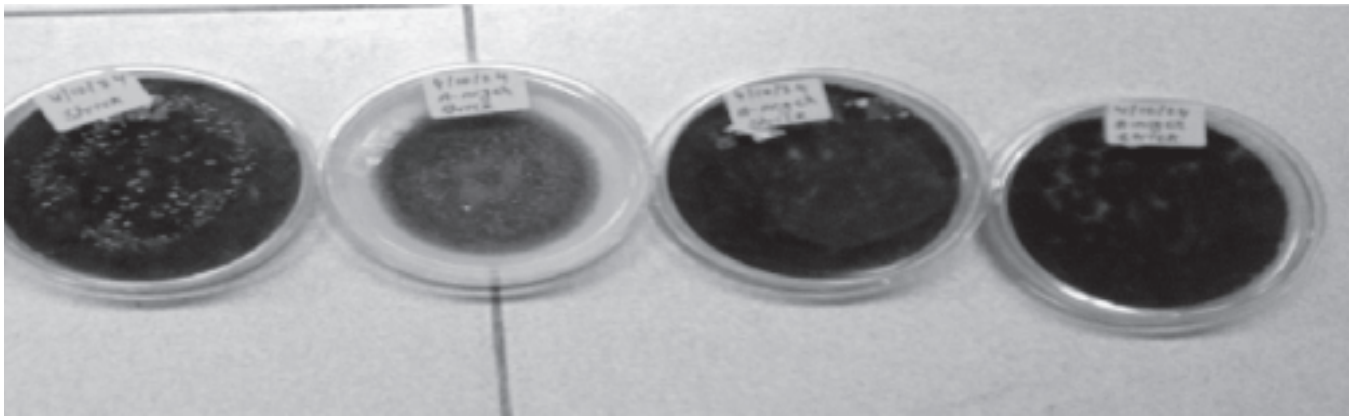

Fig. 1: Growth of *Aspergillus niger*

adaptable to different resource availabilities. The most commercially viable method for large-scale citric acid production is microbial fermentation using the fungus *Aspergillus niger* and cane molasses as a substrate[7].

Aspergillus niger is the preferred microorganism for citric acid production because of its genetic stability, high yield potential, and cost-effectiveness. This species utilizes low-cost substrates, such as cane molasses, to produce citric acid through a process known as "fungal overflow metabolism," where excess carbon is directed toward citric acid synthesis under specific conditions[10]. *A. niger* also minimizes unwanted by-products, which is advantageous for commercial production. *A. niger* can produce citric acid in high concentrations, increasing overall yield and reducing production costs. By utilizing inexpensive substrates, such as cane molasses, *A. niger* reduces the dependency on costly feedstocks. This organism is robust and genetically stable, which contributes to consistent production efficiency. The production process with *A. niger* minimizes undesirable side reactions, leading to purer citric acid output.

The objectives of this study are to produce citric acid from corn starch as a substrate using *Aspergillus niger*, to characterize the process, and to measure the yield and concentration of the citric acid produced.

Rationale of the Study

Citric acid, an organic acid widely used in the food, pharmaceutical, and cosmetic industries, is one of the most extensively produced organic acids globally. The demand for citric acid continues to rise due to its broad utility as an acidulant, preservative, and antioxidant. Industrially, citric acid is commonly produced by microbial fermentation, primarily through the utilization of *Aspergillus niger*, a well-known citric acid-producing filamentous fungus.

Corn starch presents a promising alternative substrate for citric acid production due to its availability, low cost, and high carbohydrate content, which can be hydrolyzed into fermentable sugars. Studies have shown that using agricultural by-products and starch-rich materials could reduce production costs while maintaining high yields of citric acid. Furthermore, optimizing substrate choice and fermentation conditions can improve citric acid yield and support sustainable practices within the industry.

Research into *A. niger* strains isolated from various environments has revealed that environmental conditions, such as nutrient availability and ecological niche, influence their metabolic pathways and citric acid productivity.

This study aims to isolate and optimize *A. niger* strains from environmental sources for citric acid production using cornstarch as a substrate. By identifying strains with high citric acid output and optimizing substrate utilization, this research may offer insights into sustainable biotechnological processes that could reduce production costs and environmental impact. The study also seeks to assess the efficiency and cost-effectiveness of cornstarch compared to traditional substrates, thereby potentially contributing to a more sustainable citric acid industry.

Objectives of the Study:

1. **Isolation of *Aspergillus niger* strains**: To isolate and identify *Aspergillus niger* from different environmental sources such as soil, onion, and raw coconut.
2. **Characterization of Isolates**: Purify and characterize the isolates morphologically and biochemically to confirm their identity as *Aspergillus niger*.
3. **Citric Acid Production Optimization**: To determine the optimal conditions for citric acid production using corn starch at different concentrations.
4. **Quantification and Qualitative Analysis**: To quantify the citric acid production using titration with

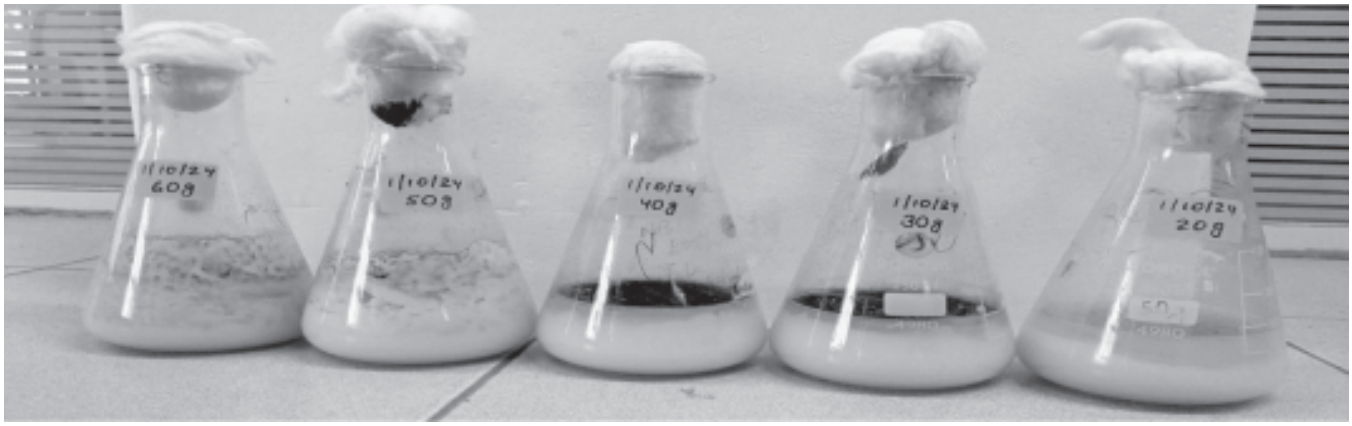

Fig. 2: Production of Ciric Acid in different concentration of Corn starch

NaOH and to qualitatively confirm the production of citric acid using bromocresol green as an indicator.

Hypothesis of the Study

1. *Aspergillus niger* isolated from environmental sources could produce citric acid when cultivated on corn starch as a substrate, with varying efficiencies based on the strain and fermentation conditions.
2. The concentration of corn starch used as a substrate would have a direct effect on citric acid production, with moderate concentrations (30%-50%) yielding the highest production.
3. The fermentation period (144 hours) would provide sufficient time for optimal citric acid production, with longer periods leading to higher yields.
4. *Aspergillus niger* strains exhibit different citric acid production capabilities, and the strain isolated from onion will demonstrate the highest production efficiency.

Materials and Methods

Sample Collection: Three samples were collected from environmental sources: soil, onion, and raw coconut. Corn cob and starch were obtained from a local market in Mumbai and stored at room temperature for further use.

Isolation of Test Microorganism (*Aspergillus niger*): To prepare a soil suspension, 1 g of the soil sample was added to a test tube containing 10 ml of sterile distilled water. A tenfold serial dilution was then performed by transferring 1 ml of the suspension into another test tube with 9 ml of sterile distilled water. This process was repeated ten times to achieve a final dilution. From each of the first three dilutions, 0.1 ml was plated onto Sabouraud dextrose agar medium and incubated for 5 to 7 days, with the same procedures used for the onion and raw coconut samples. After the incubation period, the culture's characteristics were observed, and the growth was examined under a microscope to confirm purity using the lactophenol cotton blue staining technique[2].

Production of Citric Acid from Raw Corn Starch: *Aspergillus niger* isolates were transferred into flasks, each containing raw corn starch media at different concentrations. Three flasks were prepared for each corn starch concentration: 20%, 30%, 40%, 50%, and 60%. For each concentration, 100 ml, 150 ml, 200 ml, 250 ml, and 300 ml of distilled water were used, with the volume adjusted to 500 ml by adding sterile distilled water. The flasks were autoclaved at 115°C for 10 minutes. To prepare the fungal suspension, 50 ml of distilled water was added to the fungal pure culture, and 10 ml of this suspension was then transferred to each flask. All the flasks were incubated at 28°C for 144 hours (6 days). After the incubation period, the suspension was distilled to monitor the growth and observe the results[3,4].

Detection of Citric Acid : Citric acid was detected chemically by adding three drops of bromocresol green indicator to 10 ml of the distillation yield[12,13].

Determination of Citric Acid Concentration : The concentration of citric acid was determined by titration using 0.1N NaOH and phenolphthalein as the indicator.

Result and Discussion

Isolation of *Aspergillus niger*

Three isolates of *Aspergillus niger* were obtained from three different sources: soil, onion, and raw coconut using sterile culture media. The isolates were purified, examined microscopically to

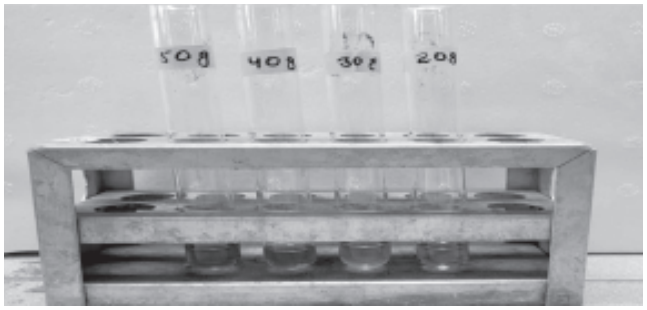

Fig.3: Detection of Citric acid

confirm their purity, and characterized based on their cultural characteristics. A total of 21 isolates were collected, with 3 (NB07, NB15, NB19) displaying morphological characteristics similar to the reference isolate, *A. niger*. All isolates demonstrated the ability to produce citric acid, though their production efficiencies varied based on their respective citric acid production indices. The onion sample NB19 proved to be the most effective sampling source for isolating citric acid-producing *A. niger* strains.

Production of Citric Acid from Raw Corn Starch

The highest citric acid yields from the strain were 10 ml, 37 ml, and 35.0 ml, which were obtained at 30%, 40%, and 50% corn starch concentration (Fig. 2). These findings are in line with previous worker[11], who reported that four *A. niger* isolates produced citric acid at concentrations ranging from 18.86±1.8 to 42.56±2. Similarly, the present findings are consistent with, earlier worker[8] who reported that citric acid production increased with the length of the fermentation period, with the maximum production occurring on day 13. However, these results contradict other[6], who found that when *A. niger* was cultured on *Parkia biglobosa* fruit pulp, the highest citric acid yield (1.15 g/L) was achieved at pH 2. The yield declined as the pH shifted from acidic to alkaline (pH 8), with a reduction in yield to 0.86 g/L.

Detection of Citric Acid

In this study, citric acid was detected chemically by adding three drops of bromocresol green indicator to 10 ml of the yield. The presence of citric acid was confirmed by a distinct color change, which indicates the acid's presence and concentration in the sample. The results of the citric acid detection and its concentration in various fermentation media showed that cornstarch-based media yielded the highest citric acid production. This aligns with previous studies, which highlighted sucrose as an effective carbon source for enhancing citric acid production in *Aspergillus niger*[12]. In contrast, the media supplemented with maltose produced the lowest yield, which could be attributed to the slower utilization of maltose by *A. niger* compared to sucrose[12,13]. The results also suggest that the concentration of sugar in the media plays a crucial role in citric acid production. Media with higher concentrations of corn starch (60%) did not show significant improvement in citric acid yields, possibly due to the inhibitory effects of high sugar concentrations, which are known to restrict microbial growth and acid production[6].

Overall, the findings suggest that corn starch and an optimal concentration (40%) is the most suitable conditions for maximizing citric acid production by *Aspergillus niger*. These conditions might be utilized in industrial applications for efficient and cost-effective citric acid production.

Determination of Citric Acid by titration method

The concentration of citric acid in the fermentation samples was determined through titration using 0.1N NaOH and phenolphthalein as the indicator. The results revealed that citric acid concentrations varied based on the carbon source, with cornstarch-based medium yielding the highest concentrations.

The highest citric acid concentration was observed in the corn starch-based medium, suggesting that cornstarch served as an efficient carbon source for *Aspergillus niger* during fermentation. This finding supports earlier studies indicating that starch, when broken down into simpler sugars, could be a suitable substrate for citric acid production[11]. In comparison, lower citric acid concentrations were obtained from other substrates, which may have been less effectively utilized by the fungus.

The titration method was successful in accurately quantifying citric acid, and the observed results highlight the potential of cornstarch as an alternative substrate for industrial citric acid production. The gradual decrease in pH observed during fermentation also suggests the ongoing production of citric acid and its contribution to the acidic environment of the medium.

Conclusion

Based on the results of citric acid detection and concentration determination, it could be concluded that corn starch serves as an effective carbon source for citric acid production by *Aspergillus niger*. The highest

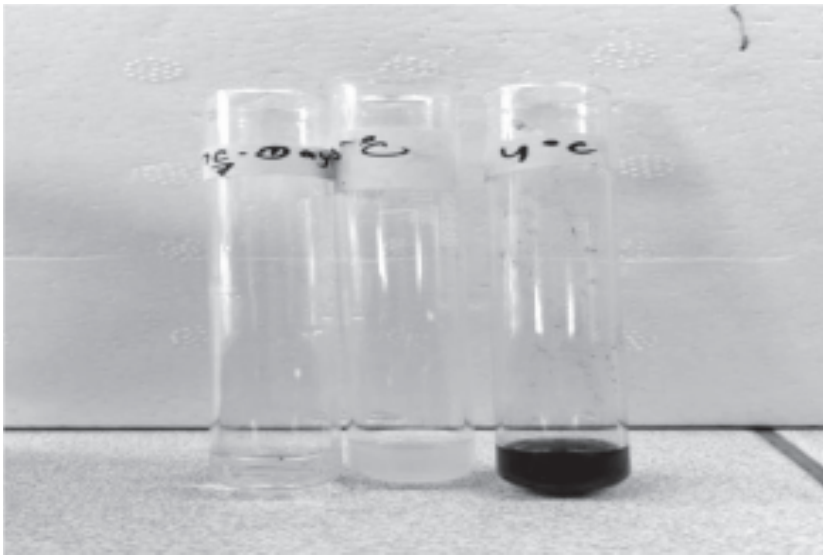

Fig 4. Determination of Citric Acid by titration method

citric acid concentrations were achieved in 40% cornstarch-based media, demonstrating its potential as a viable substrate for large-scale production of citric acid. This finding aligns with previous studies that highlight the efficiency of starch-derived sugars in fermentation processes. The titration method using 0.1N NaOH and phenolphthalein was effective in accurately quantifying citric acid, confirming the suitability of this approach for measuring citric acid production. Overall, corn starch appears to be a promising alternative to traditional carbon sources such as molasses or sugars, offering a cost-effective and efficient means of producing citric acid.

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Evaluation of nutritional, phytochemical and antioxidant properties of *Garcinia pedunculata* fruit

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ABSTRACT

This study investigates the nutritional and phytochemical composition of matured fresh fruit of *Garcinia pedunculata*, emphasizing its antioxidant properties. The proximate analysis reveals the fruit is composed of 89.44% moisture, 0.535% crude protein, 0.242% crude fat, 0.436% ash, 3.15% crude fiber, and 3.31% carbohydrates. Titratable acidity and Vitamin C content were measured at 2.89% and 36.98 mg/100g, respectively. Phenolic and flavonoid content analyses show that the ethanolic extract of the aril contains the highest concentrations, followed by the pulp. The aril's water extract also demonstrated superior phenolic and flavonoid levels compared to earlier studies. The antioxidant capacity was assessed using ABTS and DPPH assays, with the ethanolic extract of the aril exhibiting the highest activity, as indicated by lower IC_{50} values (102.9±2.8 µg/ml for ethanolic and 158±6.6 µg/ml for water extracts). The ABTS assay displayed higher sensitivity than the DPPH assay, consistent with previous findings. These results highlight *Garcinia pedunculata* as a rich source of polyphenols and flavonoids, contributing its antioxidant activity.

Figures : 03 References : 19 Tables : 03
KEY WORDS : Antioxidant activity, Flavonoids, *Garcinia pedunculata,* Phenolics, Phytochemicals

Introduction

Underutilized fruits are valued for their distinctive nutritional composition and medicinal benefits. These fruits are not cultivated on a large scale and have limited availability in local markets due to the absence of an established supply chain. Manipur is home to many such underutilized fruits, one of which is *Garcinia pedunculata*, locally known as "Hebung". This fruit possesses numerous medicinal properties and has been traditionally used in Manipur's folk medicine for treating digestive issues, stomach disorders, asthma, gout, and bone fractures [9,11,16]. It is also distributed in other states of North Eastern India and some parts of West Bengal.

Garcinia pedunculata belongs to the Clusiaceae family and typically thrives in evergreen and semi-evergreen forests, growing to a height of approximately 15–20 meters. The mature fruit exhibits a greenish-yellow hue and is primarily available from January to April, though its availability may extend until June[7]. In Manipur, the fruit is traditionally cooked with sugar and served as a special dish, particularly in the feasts of the Meitei community. In Assam, the raw fruit is commonly used for pickle making, while the ripe fruit is either eaten raw or cooked with fish, making it an integral part of Assamese cuisine[3].

As awareness of natural remedies and traditional ingredients grows, *Garcinia pedunculata* has gained attention not only for its culinary appeal but also for its

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TABLE-1 : Proximate constituent of *Garcinia pedunculata*

Parameter	% Composition (g/ 100g) FW
Moisture	89.44±0.46
Protein	0.535±0.01
Fat	0.242±0.03
Ash	0.436±0.015
Crude fibre	3.15±0.4
Titratable acidity	2.89±0.2
Carbohydrate	6.2
Vit C (mg/100g)	36.98±0.9

potential health-promoting properties. Traditionally, the plant has been utilized for many disorders like chronic phlegm, asthma, cough, bronchitis, fever, dysentery, cardiotonic and stomach-related diseases[6,8]. The pericarps of the fruits are extensively used as antiscorbutic, astringent, cooling, cardiotonic, emollient across the people of India, particularly NE states as a folklore medicine. It is also used in liver disease, spleen disorder, dyspepsia, anorexia, indigestion, difficult micturition, cough, respiratory disorders, ulcers, and skin diseases[10].

Considering its importance in ethnobotanical medicine, this study was undertaken to assess the nutritional composition, phytochemical properties, and antioxidant activities of *Garcinia pedunculata* fruit found in Manipur.

Materials and Methods

The ripe mature fruits of *Garcinia pedunculata* were collected from Kakching, Manipur (24.4975° N, 93.9863° E). The representative picture of the fruit is shown in (Fig. 1). Fruits were properly washed with plenty of distilled water and soaked the excess water with sterile tissue paper. Half of the edible portion pulp as well as aril was detached from seed using sterile steel knife was stored at cold (4°C) untiled used for proximate analysis.

Nutritional analysis : The moisture, crude protein, fat, crude fiber and ash content of the studied fruit sample were determined according to AOAC methods[1]. Carbohydrate content was calculated by difference method. Vitamin C (ascorbic acid) content of the fruit was determined by spectrophotometric method (2,4-dinitrophenyl hydrazine)[12]. Estimation of titratable acidity was performed[12].

Sample preparation : The mature *Garcinia pedunculata* fruit was separated into two portions : one is the pulp and another is the aril portion (Fig. 2). The fruit samples were chopped with a stainless-steel knife. Then the samples were dried and crushed into fine powder using kitchen blender. 10 g powder sample was infused with 100ml 70% ethanol in a 250ml flask with shaking at 160rpm (Spinix orbital shaker, Tarson) at room temperature for 24h. The extraction procedure was repeated for each 24h for continuous three days. The supernatant was pooled together and dried in rotatory vacuum evaporator at 40°C. For water extraction same procedure was followed by replacing 70% ethanol with distilled water and extractant was dried in lyophiliser.

Antioxidant assay

DPPH (2,2-Diphenyl-1-Picryl hydrazyl) assay

20 mg of extract was dissolved in 1 ml

TABLE-2 : Phenolic and flavonoid content of *Garcinia pedunculata fruit* extracts

Fruit extract	Phenolic(mg GAE/g extract)	Flavonoid(mg QE/g extract)
Ethanolic extract of pulp	9.62±0.67^{b}	7.62±4.0^{b}
Ethanolic extract of aril	13.2±0.72^{d}	11.6. ±1.7^{d}
Water extract of pulp	8.8±0.79^{a}	5.1±0.3^{a}
Water extract of aril	12.14±0.69^{c}	9.8±0.4^{c}

*****Values with the same alphabet in a column is not significant at 0.05 level*

TABLE-3 : Antioxidant activities of *Garcinia pedunculata fruit* extracts

Fruit extract	ABTS(µg/ml)	DPPH(µg/ml)
Ethanolic extract of pulp	172.3±8.5[d]	853.0±22.4[d]
Ethanolic extract of aril	102.9±2.8[b]	216.2±10.7[b]
Water extract of pulp	326.33±31[e]	1063.23±43[e]
Water extract of aril	158±6.6[c]	318.4±44.0[c]
Ascorbic acid	3.6±0.4[a]	7.2±0.6[a]

*****Values with the same alphabet in a column is not significant at 0.05 level*

methanoland used as stock for the antioxidant assay. 0.1 ml sample of different concentration was mixed with DPPH solution prepared in methanol (A_{517}=1.0±0.01) incubated for 30min at room temperature at dark. Decolourisation of purple colour was read at 517nm and calculated its percentage radical scavenging activity (%RSA) and IC_{50} of the fruit extract and standard ascorbic acid from the calibration curve. Ascorbic acid (AA) was used as standard antioxidant[17].

$$\%RSA = \frac{Acontrol - Asample}{Acontrol} X\ 100$$

2,22 -azino-bis (3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) assay

ABTS radical scavenging activity was performed[17]. The reaction mixture containing 0.1mL of extract was mixed with 1.9mL ABTS radical (A_{734}=1.0±0.01) then incubated in the dark, and the absorbance was read at 734nm after for 30min. Ascorbic acid (AA) was used as standard antioxidant. RSA and IC_{50} of the extract were calculated.

Total Phenolic and flavonoid assay : The total phenolic of the fruit extract was analyzed by Folin Ciocalteu and aluminium chloride methods, respectively[18]. Phenolic content was expressed in milligram of gallic acid equivalent per gram of extract (mg GAE/g), whereas flavonoid and content was determined differently[2] and amount is expressed in milligram of quercetin equivalent per gram of extract (mg QE/g).

Statistical analysis : All the experiments were done in triplicates and values are presented as mean standard deviation. ANOVA analysis was done using SPSS 16 software.

Results and Discussion

The proximate content of matured fresh fruit of *Garcinia pedunculata* is presented in Table-1. The fruit is constituted by moisture (89.44±0.46%), crude protein (0.535±0.01%), crude fat (0.242±0.03%), and ash (0.436±0.015%), crude fibre (3.15±0.4%)and other carbohydrates (3.31±0.87%) (Table-1). Similarly, the

Fig. 1 : *Garcinia pedunculata plant*

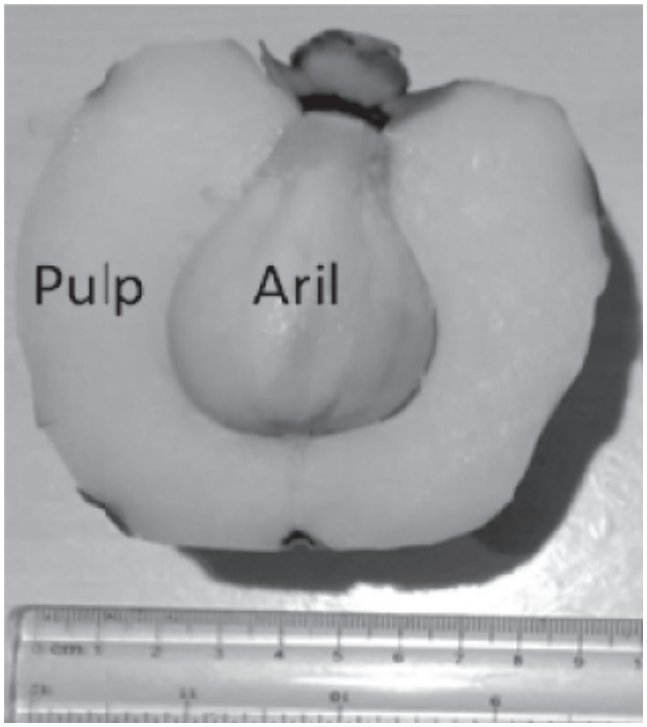

Fig. 2 : Ripe and Mature fruit of *Garcinia pedunculata* showing aril and pulp

proximate composition of *Garcina pedunculata* fruit was also reported as moisture 85%, Crude fat 0.44% ash 1.37%, Crude fibre 3.4 %. While, earlier worker[13] have reported that *Garcinia* fruit contained 88.47% moisture, 1.25% fat, 4.97 crude protein, 1.86% ash and 2.13 titratable acidity.The titratable acidity and Vitamin C content was recorded as 2.89±0.2% and 36.98±0.9 mg/100g. According to National Institutes of Health the dietary requirement of vitamin C content is 90 milligrams (mg) per day for men 75 mg per day for women. This indicates that consumption of 100 g of *Garcinia pedunculata* fresh fruit could provide approximately 1/3 of dietary requirement in men and ½ in women.

The phytochemical content of *Garcinia pedunculata* fruit extracts

The total phenolic and flavonoid content of the fruit extract is presented in Table-2. The ethanolic extract of the aril exhibited the highest levels of phenolic (13.2±0.72 mg GAE/g extract) and flavonoid compounds (11.6. ±1.7 QE/g extract), followed by the ethanolic extract of the pulp. Similarly, the water extract of the aril showed higher phenolic content (12.14±0.69 mg GAE/g extract) and flavonoid content (9.8±0.4mg QE/g extract) compared to previous findings by earlier worker[15] who reported total phenolic content (TPC) of 9.44±0.24 mg GAE/g extract and total flavonoid content (TFC) of 0.607±0.027 mg QE/g extract in the methanolic extract of *Garcinia pedunculata*. These differences could be attributed to various factors, such as climatic conditions and fruit maturity. Other ones[14] have reported that the *Garcinia pedunculata* fruit contained total phenolic content of 5.86 ±0.02 mg catechin/gram. While flavonoid content of *Garcinia pedunculata* fruit reported as 5.60 ±0.14 mg quercetin/gm. The fruit is a rich source of polyphenols and flavones. The presence of anthocyanin a well-known flavonoid is also reported[15]. Polyphenols and flavonoids are very important phytochemicals present in pants having biological activities beneficial to human health. They are excellent antioxidants[4]. These phytochemicals are used in herbal medicines. Flavonoids and various other phenolic compounds are recognized for their potent antioxidant, anticancer, and antibacterial properties. They also exhibit cardioprotective effects, anti-inflammatory benefits, and immune-boosting potential. Additionally, these compounds contribute to skin protection against UV radiation and are considered promising for pharmaceutical and medical applications[19].

Antioxidant activities of *Garcinia pedunculata fruit* extracts

The antioxidant activities of *Garcinia pedunculata* fruit extract was determined by two different methods such as ABTS and DPPH assay. The ethanolic extract of aril exhibited highest antioxidant activity in both the assays as indicated by its lower IC_{50} values (Table-3). The IC_{50} values for ethanolic and water extracts of aril was recorded as 102.9±2.8 µg/ml and 158±6.6 µg/ml respectively. The lowest antioxidant activity was observed in water extract of pulp in DPPH assay. All the extracts showed higher antioxidant activity in ABTS assay as compared to DPPH assay. This might be due

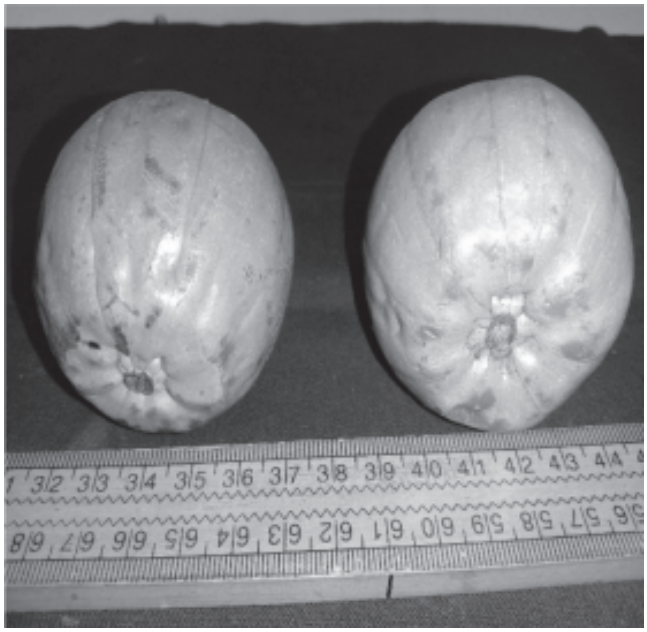

Fig. 3 : Unripe fruit

to the sensitivity of ABTS assay over DPPH assay. Similarly, investistors[5], have reported that ABTS assay might be more useful than DPPH assay for detecting antioxidant capacity in a variety of foods. Others[15] have reported the antioxidant activities of methanolic extract of *Garcinia pedunculata* fruit. The IC_{50} for DPPH was recorded as 493.30 ± 12.06µg/ml and that of ABTS as 535.70 ± 4.04 µg/ml.

Conclusion

The study highlights the rich nutritional and phytochemical composition of *Garcinia pedunculata*, emphasizing its high moisture content, essential nutrients, and significant levels of phenolic and flavonoid compounds. The ethanolic extract of the aril demonstrated the highest antioxidant activity, particularly in the ABTS and DPPH assays, indicating its potential as a potent antioxidant source. Overall, *Garcinia pedunculata* emerges as a valuable fruit with potential health benefits.

Declaration of conflict of interest

The authors declare that they have no conflict of interest.

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