ISSN 2583– 0260 (online) *ISSN 2394 -7837 (print)*

NUTRITIONAL EVALUATION IN FRUITS OF *CARICA PAPAYA* L.- CARICACEAE

Sarath Ramesan V. V., Athulya Sankar S. and *Pradeesh S.

Received: 21/3/2025 Revised:22/5/2025 Accepted:25/5/2025 Published: 30/12/2025

Abstract
Plants are nature's treasure, providing oxygen, food, shelter and medicines; while they also play a vital role in maintaining the balance of our ecosystem and supporting life on Earth. They possess immense potential as medicine, with many plants containing bioactive compounds that can be used to develop new treatments, drugs and therapies for various diseases. Phytochemicals comprising primary and secondary plant metabolites may play a key role in curative properties attributed to a particular plant. *Carica papaya* L., belonging to Caricaceae, has been valued for decades for its nutritional and medicinal properties. Preliminary phytochemical analysis of the methanolic extract shows the presence of reducing sugar, flavonoids, alkaloids, tannins, terpenoids, steroids, coumarins and glycosides. Nutritional factors such as reducing sugar, total carbohydrates, total proteins, pigments, starch and amino acids were analysed by standard estimation procedures and were found to have very higher amounts. Antinutritional factors like total phenol, phytic acid and tannic acid were analysed by standard estimation methods and found at very low concentration. Different non-enzymatic antioxidants like proline, lycopene, carotenoids, total polyphenols, Vitamin-E and enzymatic antioxidants like superoxide dismutases (SOD), catalase (CAT), glutathione reductase (GR), peroxidase (POD), amylase, polyphenol oxidase (PPO) and lipid peroxidase (LP_X) were estimated quantitatively by standard estimation procedures and found in moderately higher amounts. Antimicrobial activity of crude methanolic extract of *Carica papaya* was evaluated by agar well diffusion method and revealed no antimicrobial property. *In vitro* anticancer analysis in crude methanolic extract in ECA (Ehrlich's Ascites Carcinoma) and DLA (Dalton's Lymphoma Ascites) cell lines revealed promising anticancer effects. The present study evaluated various nutritional, antinutritional, antimicrobial and medicinal properties of the plant *Carica papaya*, exhibiting diverse potentialities of the plant and providing supporting information for its use as an ethnomedicinal plant of the present life.

Keywords: *Carica papaya,* Caricaceae, ECA, DLA

Introduction

Plants are a rich source of medicinal compounds, serving as the foundation for modern medicines, nutraceuticals, nutritional supplements and pharmaceuticals (Chowdhury, 2022). Indian medicinal plants play a pivotal role in the traditional system of medicine. They have been successfully used in the treatment of diverse pathological conditions, including respiratory disorders (bronchial asthma, chronic cough), infectious diseases (malaria, dysentery), diabetes, neurological manifestations (convulsions), dermatological ailments and gastrointestinal, hepatic, cardiovascular and immunological disorders (Yadav and Agarwala, 2011).

Phytochemicals are the chemicals that are naturally present in plants. They are non-nutritive plant chemicals that have either defensive or disease-protective properties.

Phytochemicals scientifically classified into major groups including phytoestrogens, terpenoids, carotenoids, limonoids, phytosterols, glucosinolates and various phenolic compounds (notably polyphenols, flavonoids, isoflavonoids and anthocyanidins). These phytochemicals demonstrate significant potential in modern healthcare systems. Their therapeutic value is evidenced through both preventive and treatment applications for various pathological conditions, with common dietary sources including whole grains, legumes, fruits, vegetables and medicinal herbs. Emerging evidence suggests that phytochemicals, either individually or synergistically, exhibit substantial therapeutic efficacy in the management of diverse pathological conditions

Post Graduate Department and Research Centre of Botany, Mahatma Gandhi College, Kesavadasapuram, Thiruvananthapuram, Kerala, India – 695004. (Affiliated to University of Kerala, Thiruvananthapuram, Kerala, India), **email: pradeeshnair10@gmail.com (corresponding Author)*

(Prakash *et al.,* 2012). Fruits serve as rich sources of natural antioxidants, including carotenoids, phenolic compounds, flavonoids, dietary glutathione and various endogenous metabolites. Humans have long relied on plants to meet their daily requirements ranging from food and shelter to fiber and medicinal applications. Medicinal plants, in particular, are valued for their diverse array of physiologically active constituents, such as minerals and phytochemicals, which exert numerous beneficial effects on human health (Dagli *et al*., 2015).

Members of the family Caricaceae possess various medicinal and pharmacological properties. Regular consumption of papaya after meals has been shown to support digestive health by minimizing bloating and alleviating chronic indigestion. It is also reported to reduce nausea, vomiting and morning sickness in pregnant women. Additionally, evidence indicates that papaya can enhance iron absorption from rice-based diets among Indian women (Ballot *et al*., 1987). The fresh fruit is used as a carminative, stomachic, diuretic and antiseptic in many parts of the world (Bhattacharjee, 2001). Papaya can strengthen the immune system, helping to prevent recurrent colds and flu. Additionally, consuming papaya or its juice after antibiotic treatment may aid in replenishing beneficial intestinal microflora (Murcia, 2001).

Materials and Methods

Collection of Sample

Carica papaya was collected from Kesavadasapuram, Thiruvananthapuram district of Kerala. The plant specimen was made into a herbarium and deposited in the herbarium repository of the Botanical Survey of India (BSI), Southern Regional Centre (SRC), Coimbatore-3 and authenticated (BSI authentication number: 431). For sample preparation fresh immature fruit were separated, shade dried, ground well using a mechanical blender to a fine powder and transferred into air-tight containers for further analysis.

Preparation of plant extract

The dried plant materials were extracted with methanol for 8 hours using a Soxhlet apparatus, yielding a brownish-yellow liquid extract. After which, the residues were transferred to a pre-weighted sample container for storage.

Extraction from Plant Parts

The fine powder was used for extraction with the methanol solvent. Fifty grams of sample powder were kept in the Soxhlet apparatus for distillation. Methanol was taken in the round-bottom flask. The apparatus was kept over a heating mantle and heated for 8 hours at 70°C. After completing the process, the extract was collected in a beaker and kept in an oven at 37°C - 40°C. The crude concentrated extract was again weighed and used for further biochemical analysis.

Preliminary phytochemical analysis

The different phytochemicals like reducing sugar, alkaloids, flavonoids, steroids, tannins, terpenoids, glycosides, coumarins, saponins, anthraquinones, phlobatannins and iridoids, were tested (Harborne, 1977).

Biochemical analysis

Nutritional Analysis

The different nutritional factors like like reducing sugar (Miller, 1959), total carbohydrates (Hedge and Hofreiter, 1962), total proteins (Lowry *et al*., 1951), starch (Thayumanavan and Sadasivam, 1984), pigments (Witham *et al*., 1971), carotenes (Lichtenthaler and Wellburn, 1983) and amino acids (Moore and Stein, 1948) were estimated.

Antinutritional analysis

Antinutritional factors like total phenols (Mayer *et al*., 1995), phytic acid (Wheeler and Ferrel, 1971) and tannic acids/tannins (Schanderi, 1970) were analysed.

Evaluation of Medicinal Properties

Non-enzymatic Antioxidants

The different non-enzymatic antioxidants like proline (Bates *et al*., 1973), lycopene (Zakaria *et al*. 1979), total polyphenols (Eom *et al*., 2008), carotenoids (Jagessar, 2017) and α-tocopherol (Rosenberg, 1992) were quantified.

Enzymatic Antioxidants

Enzymatic antioxidants like superoxide dismutase (Gong *et al*., 2005), catalase (Cakmak *et al*., 1993), glutathione reductase (Foyer and Halliwell, 1976), peroxidase (Putter (1974), amylase (Miller, 1959), polyphenol oxidase (Esterbauer *et al*., 1991) and lipid peroxidase (Zhang and Kirkham, 1996) were estimated.

Antibacterial Activity in *Carica papaya*

Procedure

The agar well diffusion method is widely used to evaluate the antimicrobial activity of the test sample. Mueller-Hinton agar (15-20 ml) was poured on glass petriplates of the same size and allowed to solidify. Standardized inoculum of the test organism was uniformly spread on the surface of the plates using a sterile cotton swab. Four wells with a diameter of 8 mm (20 mm apart from one another) were punched aseptically with a sterile cork borer in each plate. The test sample (50 and 100 µl) was added into the wells T1 and T2 from a 10 mg/ ml stock. Gentamycin (40 µl from 4 mg/ml stock) and the solvent used for sample dilution (DMSO) were added as positive and negative controls respectively. The plates were incubated for 24 hours at 36°C ± 1°C, under aerobic conditions. After incubation, the plates were observed and the zone of bacterial growth inhibition around the wells was measured in mm (Valgas *et al*., 2007).

Culture media

Muller Hinton Agar medium (HIMEDIA-M173) is used for determination of susceptibility of microorganisms to antimicrobial agents. Suspend 38 grams in 1000 ml distilled water. Heat until it boils to dissolve the medium completely. Sterilize by autoclaving at 15 lbs pressure (121°C) for 15 minutes. Cool to 45-50°C. Mix well and pour into sterile petri plates.

Inoculums

The microbial inoculums were obtained from the Microbial Type Culture Collection (MTCC), Chandigarh. The strains used in the study included *Pseudomonas aeruginosa* (MTCC 741) and *Streptococcus pyogenes* (MTCC 442). All cultures were incubated at 37 °C for 24 hours under standard laboratory conditions before experimentation.

Antifungal Activity
Procedure

Agar well diffusion method is widely used to evaluate the antimicrobial activity of the test sample. Mueller-Hinton agar and Potato Dextrose Agar MH096 Himedia in the ratio 1:1 was poured on glass petri plates of same size and allowed to solidify. Standardized inoculum of the test organism was uniformly spread on the surface of the plates using sterile cotton swab. Four wells with a diameter of 8 mm (20 mm apart from one another) were punched aseptically with a sterile cork borer in each plate. The test sample (50 and 100 µl) was added into the wells T1 and T2 from 10mg/ml stock. Clotrimazole (40 µl from 300 mcg/ml stock) and the solvent used for sample dilution (DMSO) were added as positive and negative control respectively. The plates were incubated for 48 hours at 27ºC ± 1ºC, under aerobic conditions. After incubation, the plates were observed and the zone of bacterial growth inhibition around the wells was measured in mm (Magaldi *et al*., 2004).

Culture medium

Mueller-Hinton agar and Potato Dextrose Agar MH096 Himedia (in the ratio 1:1) was used for determination of susceptibility of fungal strains to antifungal agents. Heat the medium until it boils to dissolve the medium completely. Sterilize by autoclaving at 15 lbs pressure (121°C) for 15 minutes. Cool to 45-50°C. Mix well and pour into sterile petriplates.

Inoculum

The fungal inoculums were procured from the Microbial Type Culture Collection and Gene Bank (MTCC), Chandigarh. The strains included *Aspergillus niger* (MTCC 872) and *Rhizopus stolonifer* (MTCC 952). All cultures were incubated at 27°C for 48 hours under standard laboratory conditions before use.

Evaluation of Pharmacological property
***In vitro* Anticancer Activity in Crude Methanol Extract**

Anticancer effect of crude methanol extract of

Carica papaya was evaluated by using DLA and EAC cell lines. The crude methanol extract from *Carica papaya* at high concentration damaged the cells and make pores on the membrane through which Trypan blue enters. The damaged cells are stained with Trypan blue stain and can be distinguished from viable cells. Since live cells are excluded from staining, this method is also known as dye exclusion method (Pradeesh and Swapna, 2018) .

Dalton's lymphoma Ascites Cells (DLA) and Ehrlich Ascites Carcinoma (EAC)

Varying concentrations (100, 500, 1000 µg/ml) of crude methanol extract *Carica papaya* of were prepared. The cancer cells were aspirated from peritoneal cavity of cancer bearing mice and were washed thrice with normal saline. The cell suspensions (1×10^6 DLA/ EAC cells in 0.1 ml) were added to a tube containing various concentration of test extract (100, 500, 1000 µg/ ml) and the volume was made up to 1 ml using phosphate buffer saline (PBS). The control tube contained only cell suspension. The mixture was incubated for 3 hours at 37^o C and was then stained with two drops of Trypan blue dye. Dead cells take up the blue colour of Trypan blue while live cells do not. Further percentages of dead cells were evaluated by Trypan Blue Exclusion method. The numbers of stained and unstained cells were counted separately (Pradeesh and Swapna, 2018).

% Dead cells = (Number of Dead cells/ Number of viable cells + Number of Dead cell) × 100

Results and Discussion

Qualitative Analysis

Preliminary Phytochemical Screening

Phytochemical screening revealed the presence of reducing sugar, flavonoids, alkaloids, tannins, terpenoids, steroids, glycosides and coumarins. But the presence of saponins, phlobatannins, iridoids, and anthroquinone were not detected (Table 1).

Quantitative Analysis

Nutritional Evaluation

Plants are a primary source of nutrition for humans and animals, providing essential nutrients, fiber and energy in the form of carbohydrates, fats, proteins etc. Different components of plants serve as nutritional aids to humans, so the search for these components from plants is becoming relevant. Nutritional factors present in *Carica papaya* like reducing sugar, total carbohydrates, total proteins, starch and pigments were analysed quantitatively.

Reducing sugars are a category of carbohydrates that can act as reducing agents because they possess a free aldehyde or ketone group. Common examples of reducing sugars include glucose, fructose, lactose and maltose. The significance of reducing sugars extends to nutrition and health (Baptista *et al.,* 2018). Reducing sugar from the immature fruits of *Carica papaya* was extracted and analysed by Dinitrosalicylic acid (DNS) method and the results were found to be low (0.223 mg g^{-1}) as shown in figure 1.

Carbohydrates serve as a primary source of energy for the body, particularly for the brain and muscles during physical activity. Carbohydrates are classified into three main types they are monosaccharides, disaccharides and polysaccharides. Carbohydrates play several vital roles including providing energy, regulating blood glucose levels and sparing the use of proteins for energy (Whitney *et al*., 2022). The amount of total carbohydrates in *Carica papaya* was found to be high (9.619 mg g^{-1}) as shown in figure 2.

Proteins are complex biomolecules that play a vital role in nearly all cellular processes. They are the building blocks of life, essential for growth, development and maintenance of body tissues. Proteins are composed of amino acids, which are linked together in a specific sequence to form a polypeptide chain. They are engaged in building and repairing tissues, maintaining *p*H balance, the defence mechanism and transportation of molecules (Ghaly and Alkoaik, 2010). The amount of proteins in fruits of *Carica papaya* is 12.349 mg g^{-1} (figure 2).

Chlorophyll is a green pigment found in plants, algae and cyanobacteria that plays a crucial role

Table 1. Preliminary phytochemical analysis of *Carica papaya* in methanolic extract

Sl. Number	Phytochemicals	Methanolic extract of *Carica papaya*
1	Reducing sugar	+
2	Flavanoids	+
3	Alkaloids	+
4	Tannins	+
5	Terpenoids	+
6	Steroids	+
7	Coumarins	+
8	Glycosides	+
9	Saponins	-
10	Phlobatannins	-
11	Iridoids	-
12	Anthroquinone	-

(+ denotes presence, - denotes absence)

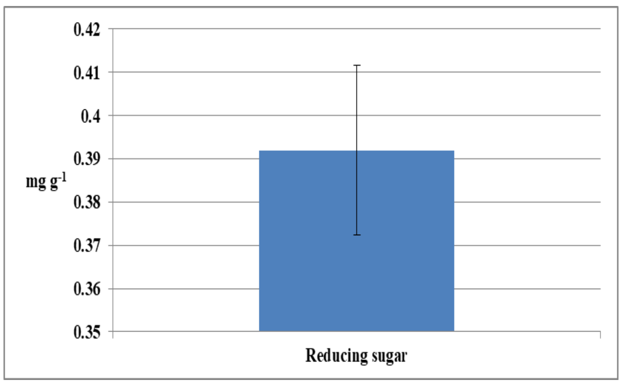

Figure 1. Reducing sugar in immature fruits of *Carica papaya*

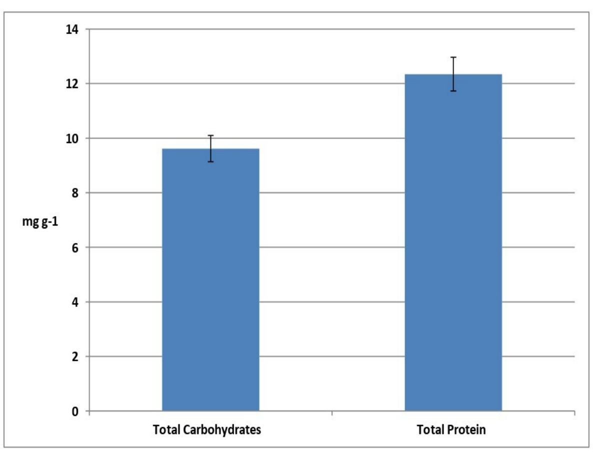

Figure 2. Total carbohydrates and Total protein in immature fruits of *Carica papaya*

Plate 1.Antibacterial activity in *Pseudomonas aeruginosa*

Plate 2.Antibacterial activity in *Streptococcus pyogenes*

in photosynthesis. It absorbs light energy from the sun and transfers energy to other molecules, powering photosynthesis. Chlorophyll-a is the most common form of chlorophyll and is found in all photosynthetic organisms. Chlorophyll-b is the accessory pigment that absorbs light energy and transfers it to chlorophyll-a, supporting photosynthesis (Mishra *et al*., 2011). The different pigments in *Carica papaya* were estimated and found to be high (chlorophyll-a: 0.964 mg g^{-1}, chlorophyll-b: 0.826 mg g^{-1}, total chlorophyll: 1.243 mg g^{-1}) as shown in figure 3.

Carotene, particularly beta-carotene, is a provitamin-A carotenoid that the body converts into Vitamin-A, essential for vision, immune function, and skin health. It also acts as an antioxidant, protecting cells from oxidative damage.

Dietary sources include carrots, sweet potatoes and leafy greens (National Institutes of Health, 2021). The amount carotenes in fruit of *Carica papaya* were found to be 1.092 mg g^{-1} (figure 3).

Starch is the reserve food material of plants which serves as a storage of energy and a carbon source. Starch is made up of two polysaccharides (amylose and amylopectin. Starch is used as a thickening agent in sauces and as a colloidal stabilizer in salad dressings (Manthey and Xu, 2009). The amount of starch in *Carica papaya* was found to be 0.691 mg g^{-1} (figure 4).

Amino acids are building blocks of proteins. They are bifunctional compounds containing both an amine group and a carboxylic acid group (Finar, 1973). There are nine essential amino acids, which cannot be synthesised in the body and if one of these is provided in inadequate amounts regardless of the total protein intake, it will not be possible to maintain nitrogen balance. The importance of amino acids cannot be overemphasized as they form the basement or building blocks of the molecular structure of the important and very complex class of compounds known as proteins. The amount of amino acids in *Carica papaya* were found a high amount of tyrosine (0.924 mg g^{-1}), serine (0.826 mg g^{-1}), aspartic acid (0.146 mg g^{-1}), methionine (0.981 mg g^{-1}), phenylalanine (0.821 mg g^{-1}), glycine (0.872 mg g^{-1}), proline (0.825 mg g^{-1}), cysteine (0.697 mg g^{-1}), isoleucine (0.569 mg g^{-1}) as shown in figure 5.

Anti-nutritional Evaluation

Wild edible plants consumed by tribal people are rich in several nutrients. However, the main problem related to the nutritional exploitation of these plants is the presence of antinutritional and toxic compounds (Guil *et al*., 1997). Antinutritional factors can be defined as substances generated in natural feedstuffs through the normal metabolism of the species and various mechanisms, including the inactivation of certain nutrients, the diminution of the digestive process, or the metabolic utilization of feed, which exert effects on optimal nutrition (Kumar, 1983).

Total phenols are a group of plant secondary metabolites characterized by hydroxylated aromatic rings which despite their beneficial antioxidant properties, also exhibit notable antinutritional effects (Makkar *et al*., 1995). Total phenols present in *Carica papaya* found to be very low (0.0477 mg g^{-1}) as shown in figure 6.

Phytic acid also known as myo-inositol hexakisphosphate. It is a naturally occurring storage form of phosphorus found predominantly in seeds, legumes and cereals. Although it plays a vital role in plant physiology. Phytic acid is widely recognized as an antinutritional factor in human and animal nutrition due to its strong chelating properties (Hurrell, 2003). The amount of phytic acid in *Carica papaya* is 0.028 mg g^{-1} (figure 6) and is found to be low.

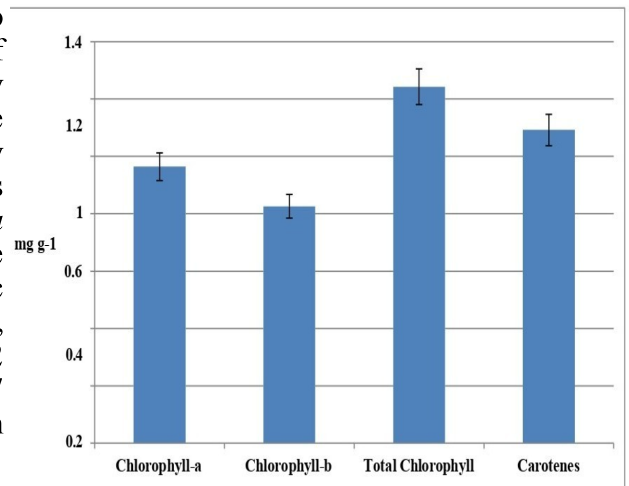

Figure 3. Pigments in immature fruits of *Carica papaya*

Tannic acid, a type of hydrolyzable tannin is a polyphenolic compound found in various plant sources such as legumes, tea, sorghum and tree bark. Although known for its antimicrobial and antioxidant properties, tannic acid is considered an important antinutritional factor, particularly in the nutrition of monogastric animals and humans (Jansman, 1993). The amount of tannic acid in *Carica papaya* was found to be very low (0.032 mg g^{-1}) as shown in figure 6.

Evaluation of Antioxidant Properties

Plants are a rich source of antioxidants, which help protect cells from damage caused by free radicals. Antioxidants play a crucial role in maintaining overall health by neutralizing free radicals, reducing inflammation, protecting cells, supporting immune function, etc. Evaluation of enzymatic and non-enzymatic antioxidants in *Carica papaya* can help in understanding the therapeutic potential of the plant in terms of its antioxidant properties.

Non-Enzymatic Antioxidants:

Proline is a non-essential amino acid, one of the building blocks of proteins which can be synthesized by the body itself. Proline is involved in the formation of collagen, a key component of connective tissue. It is involved in cell signaling pathways, influencing cell growth and differentiation (Szabados and Arnould, 2010). The amount of proline in *Carica papaya* was found to be high (1.389mg g^{-1}) as shown in figure 7.

Lycopene is a powerful antioxidant and carotenoid pigment found in certain fruits and vegetables. It has been shown to have anti-cancer properties particularly in reducing the growth and proliferation of cancer cells. Lycopene can neutralize free radicals, unstable molecules that damage cells and contribute to chronic diseases (David and Lu, 2002). The amount of lycopene in *Carica papaya* was 1.924 mg g^{-1} and found to be high (figure 7).

Carotenoids are a family of colourful pigments found in nature, responsible for the vibrant hues of fruits, vegetables and flowers. These yellow, orange and red compounds play a crucial role in maintaining the health of plants and humans alike. Carotenoids can quench highly reactive singlet oxygen and block free radical mediated reactions (Bendich and Olson, 1989). The amount of carotenoids in *Carica papaya* was found to be high (1.086 mg g^{-1}) as shown in figure 7.

Polyphenol compounds are a diverse group of bioactive organic compounds that have been known for their remarkable health benefits, antioxidant properties and potential to prevent chronic diseases. They are abundant in fruits, vegetables, herbs and spices, making them an integral part of a healthy diet (Abbas *et al*., 2017). The amount of total polyphenols in *Carica papaya* was 0.953 mg g^{-1} (figure 7).

Tocopherols or Vitamin-E, primarily in the form of α-tocopherol, a fat-soluble vitamin that functions as a major non-enzymatic antioxidant in biological systems. It plays a critical role in protecting cellular components, especially polyunsaturated fatty acids in membrane lipids, from oxidative damage caused by free radicals and reactive oxygen species (ROS) (Traber and Atkinson, 2007). The amount of Vitamin-E in *Carica papaya* was found to be 0.849 mg g^{-1} (figure 7).

Enzymatic Antioxidants

Superoxide dismutase (SOD) is an enzyme that plays a crucial role in protecting cells from damage caused by free radicals. SOD converts superoxide radicals (O_2-) into hydrogen peroxide (H_2O_2) and oxygen (O_2), neutralizing the harmful effects of superoxides (Shingo *et al*., 1994). Phytochemical analysis revealed the amount of Superoxide dismutase in *Carica papaya* was found to be high (2.369 mg g^{-1}) as shown in Fig. 8. Catalase is a heme-containing enzyme that catalyzes the dismutation of hydrogen peroxide into water and oxygen. This enzyme is found in all aerobic eukaryotes and is important in the removal of H_2O_2 generated in peroxisomes (microbodies) by oxidases involved in β-oxidation of fatty acids, the glyoxylate cycle (photorespiration) and purine catabolism (McKersie, 1996). Phytochemical analysis revealed the amount of catalase in *Carica papaya* was 1.916 mg g^{-1} and found to be high (figure 8).

Glutathione reduces the formation of toxic lipid peroxide and hydrogen peroxide in the biological system by acting as a substrate for glutathione peroxidase. Glutathione has been shown to be an effective anticarcinogen against a wide range of carcinogen. Glutathione can function as an antioxidant in many ways (Prince *et al*., 1990). Phytochemical analysis revealed the amount of glutathione reductase in *Carica papaya* was found to be high (1.629 mg g^{-1}) as shown in figure 8.

Peroxidase (POD) catalyses the dehydrogenation of a large number of organic compounds such as phenols, aromatic amines, hydroquinones etc. POD occurs in animals, higher plants and other organisms (Putter, 1974). Phytochemical analysis revealed that the amount of peroxidase in *Carica papaya* was found to be 1.824 mg g^{-1} (figure 8). Amylases are a group of enzymes that play a crucial role in the breakdown of starches into simple sugars. These enzymes are found in various organisms, including humans, animals, plants and microorganisms. Amylases are responsible for hydrolyzing the glycosidic bonds in starch molecules, producing shorter-chain sugars like maltose, glucose and dextrins (Pradeesh and Swapna, 2018). The amount of amylase in *Carica papaya* was found to be high (0.896 mg g^{-1}) as shown in figure. 8.

Polyphenol oxidases (PPOs) are a group of enzymes that play a crucial role in the metabolism of polyphenolic compounds in plants and animals. PPOs catalyse the oxidation of polyphenolic compounds, leading to the formation of quinones, which can react with other molecules to form brown pigments (Yoruk and Marshall, 2003). Analysis revealed the amount of polyphenol oxidase in *Carica papaya* was found to be 0.963 mg g^{-1} (figure 8).

Lipid peroxidase (LPx) an enzyme that catalyses the oxidation of lipids, leading to the formation of lipid peroxides. This process can cause cellular damage, inflammation and contribute to various diseases. Lipid peroxidase is present in various tissues, including the liver, kidneys, brain and red blood cells. Its activity is regulated by antioxidants, free radical scavengers and enzyme inhibitors (Pradeesh and Swapna, 2018). Phytochemical analysis revealed that the amount of lipid peroxidase in *Carica papaya* was found to be high (0.823 mg g^{-1}) as shown in figure 8.

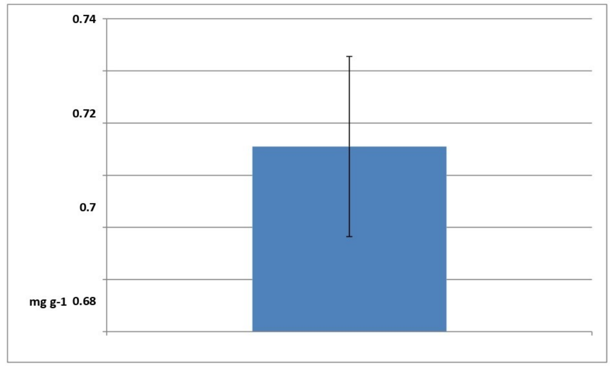

Figure 4. Starch in immature fruits of *Carica papaya*

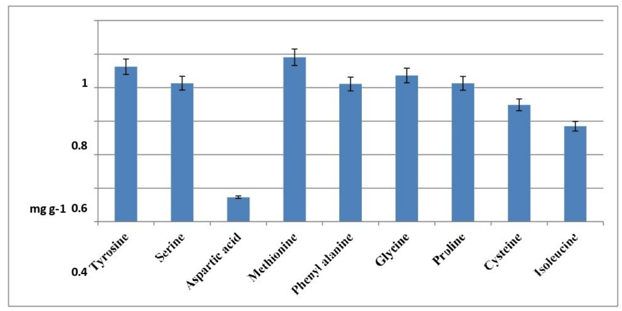

Figure 5.Amino acids in immature fruits of *Carica papaya*

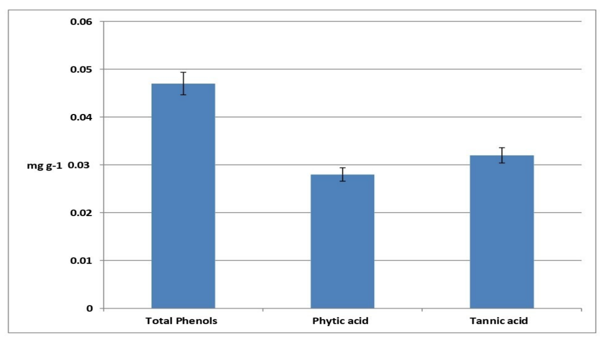

Figure 6. Antinutritural factors in immature fruits of *Carica papaya*

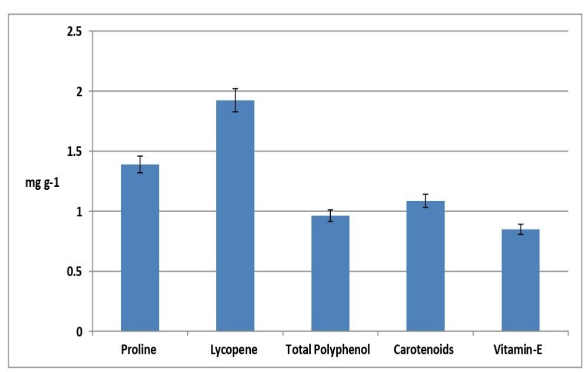

Figure 7. Non-Enzymatic Antioxidants in immature fruits of *Carica papaya*

Antibacterial activity of *Carica papaya* against two bacterial strains of *Pseudomonas aeruginosa* and *Streptococcus pyogenes* was evaluated. Results showed that the methanolic extract of *Carica papaya* was not effective against both strains (Table 2 and Plate 1 and Plate 2).

Antifungal activity of *Carica papaya*

Methanolic extract of immature fruit is not active against the fungi, *Aspergillus niger* and *Rhizopus stolonifer* (Table 3, Plate 3 and Plate 4).

Evaluation of Pharmacological Property

In vitro*Anticancer Activity in Crude Methanol Extract of *Carica papaya

Plants are known to be effective in treating various diseases since ancient times. Cancer is one of the leading fatal diseases of man. The relevance of active compounds present plants in treating malignant tumours and preventing cancer is acquiring more popularity in recent years. Plants have been used for centuries in traditional medicine to treat various diseases and health conditions. Many plants have been found to possess anticancerous properties and research has identified various bioactive compounds responsible for these effects.

Present study evaluated *in vitro* anticancer activity of *Carica papaya* immature fruit extract in methanol. Anticancer effect was analysed using Dalton's Lymphoma Ascites (DLA) and Ehrlich Ascites Carcinoma (EAC) cell lines. The result obtained from anticancer study revealed that the extract of *Carica papaya* showed 25.920, 29.825 and 35.108% cytotoxicity in EAC compared to 27.141, 32.942 and 43.364% cytotoxicity in DLA at concentrations of 100, 500 and 1000 µg/ml. The results obtained in the present study demonstrated that the methanol extract of the immature fruit of *Carica papaya* exhibits *in vitro* anticancer activity against DLA and EAC cell lines (Table 4 and Figure 9). The immature fruit extract showed concentration-dependent cytotoxicity, which was found to be less effective against solid tumours induced by DLA and ascites tumours induced by EAC. Fijesh (2011), reported that the extract- treated cells showed membrane blebbing, vacuole formation and nuclear condensation, which was absent in untreated cells. Thus, the cytotoxic and antitumor effects of the immature fruit extract can provide possibilities to novel therapeutic findings for treating cancer cells

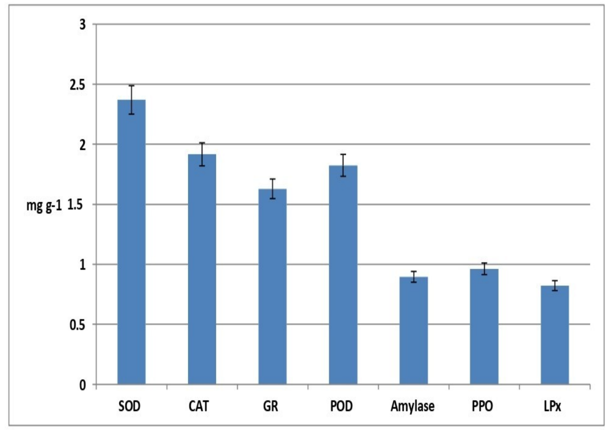

Figure 8. Enzymatic Antioxidants in immature fruits of *Carica papaya*

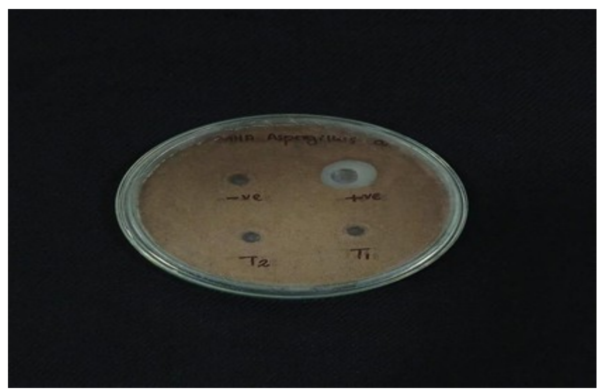

Plate 3.Antifungal activity in *Aspergillus niger*

Plate 4. Antifungal activity in *Rhizopus stolonifer*

Table 2: Antibacterial activity of the methanolic immature fruit extract of *Carica papaya*

Name of Microorganism	Gram +/-	Zone of inhibition (mm)			
		Standard Gentamycin (160 µg)	Negative control	T1 (500µg)	T2 (500µg)
Pseudomonas aeruginosa	-ve	+ve (26mm)	-ve	-ve	-ve
Streptococcus pyogenes	+ve	+ve (20mm)	-ve	-ve	-ve

Table 3: Antifungal activity of the methanolic immature fruit extract of *Carica papaya*

Name of Microorganism	Zone of inhibition			
	Standard Clotrimazole (120µg)	Negative control	T1 (500 µg)	T2 (500 µg)
Aspergillus niger	+ve (17mm)	-ve	-ve	-ve
Rhizopus stolonifera	+ve (16mm)	-ve	-ve	-ve

Table 4. *In vitro* anticancer activity in crude methanol immature extract of *Carica papaya*

Concentration (µg/ml)	Standard%	DLA%	EAC%
100	60.908	25.92	25.92
500	86.39	32.942	29.825
1000	98.19	43.364	35.108

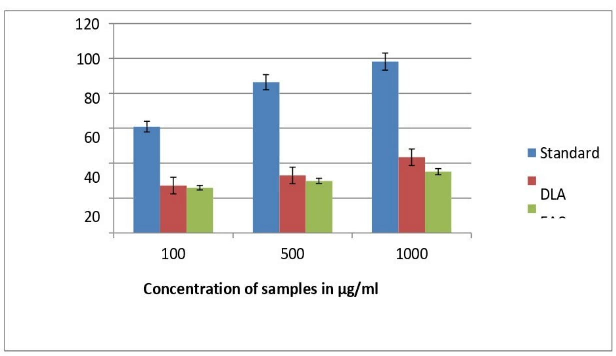

Figure 9. *In vitro* anticancer activity in immature fruit extract of *Carica papaya*

Summary and Conclusion

Carica papaya, commonly called pawpaw tree or papaya tree, belongs to Caricaceae. The present study on *Carica papaya* is concerned with preliminary phytochemical analysis, quantitative estimation of nutritional, antinutritional and antioxidant properties and *in vitro* anticancer analysis on DLA and EAC cell lines. Preliminary phytochemical screening in methanolic extract of immature fruit of *Carica papaya* revealed the presence of reducing sugar flavonoids, alkaloids, tannins, terpenoids, steroids, glycosides and coumarins. But presence saponins phlobatannins, iridoids and anthroquinone were not detected. Quantitative analysis of biochemicals related to nutrition revealed that immature fruits of the plant contain higher amounts of carbohydrates and protein and a reasonable amount of reducing sugar. Non-enzymatic antioxidants such as proline, lycopene, carotenoids, total polyphenols, Vitamin-E and enzymatic antioxidants such as superoxide dismutases, catalase, glutathione reductase, peroxidase, amylases, polyphenol oxidases and lipid peroxide were quantified. Among these, enzymatic antioxidants such as superoxide dismutases, catalase, glutathione reductase, polyphenol oxidases and lipid peroxidase were found to be higher. Anticancer analysis shows the concentration dependent anticancer effect in DLA and EAC cell lines which was found to be low to moderate. This generated information on the nutritional quality of *Carica papaya* fruits provides scientific evidence supporting the identification of this plant as a valuable bioresource. The nutritional attributes underscore the fruit's therapeutic potential and highlight its effective utilisation in functional foods, nutraceuticals, and future health-promoting applications.

Acknowledgement

The authors are greateful to Dr. Manoj G. S., Assistant Professor, Department of Botany and Professor (Dr.) Balamurali R.S., Principal in charge, Mahatma Gandhi College, Kesavadasapuram, Thiruvananthapuram for valuable suggestions and encouragements.

References

Abbas, M., Saeed, F., Anjum, F. M., Afzaal, M., Tufail, T., Bashir, M. S., & Suleria, H.A. R. (2017). Natural polyphenols: An overview. *International Journal of Food Properties*, 20(8), 1689-1699.

Ballot, D., Baynes, R. D., Bothwell, T. H., Gillooly, M., Macfarlane, B. J., MacPhail, A. P., Lyons, G., Derman, D. P., Bezwoda, W. R., & Torrance, J. D. (1987). The effect of fruit juices and fruits on the absorption of iron from a rice meal. *British Journal of Nutrition*, 57, 331-343.

Baptista, J. A., Tavares, J. F., & Carvalho, R. C. (2018). Sugar content in some food products. *Food Chemistry*, 243, 320-326.

Bates, L. S., Waldren, R. P., & Teare, I. D. (1973). Rapid determination of free proline for water stress studies. *Plant and Soil, 39*, 205-207.

Bendich, A. D., & Olson, J. A. (1989). Biological actions of carotenoids. *The Federation of American Societies for Experimental Biology Journal*, 3(8), 1927-1932.

Bhattacharjee, S. K. (2001). *Carica papaya*. In S. Jain (Ed.), Handbook of medicinal plants. Pointer Publishers. 3, 1-71.

Cakmak, I., Strbac, D., & Marschner, H. (1993). Activities of hydrogen peroxide scavenging enzymes in germinated wheat seeds. *Journal of Experimental Botany, 44*, 127-132.

Chowdhury, S. (2022). Identifying phytochemical constituents of *Coccinia grandis* and identifying efficacy of *Coccinia grandis* against *Salmonella* species and *E. coli* (Doctoral dissertation, Chattogram Veterinary & Animal Sciences University).

Dagli, N., Dagli, R., Mahmoud, R. S., & Baroudi, K. (2015). Essential oils, their therapeutic properties, and implication in dentistry: A review. *Journal of International Society of Preventive and Community Dentistry*, 5, 335-340.

David, H., & Lu, Q. Y. (2002). Overview of mechanisms of action of lycopene. *Experimental Biology and Medicine*, 227(10), 920-923.

Eom, S. H., Park, H. J., Jin, C. W., Kim, D. O., Seo, D. W., & Jeong, Y. H. (2008). Changes in antioxidant activity with temperature and time in *Chrysanthemum indicum* L. teas during elution processes in hot water. *Food Science and Biotechnology, 17*, 408-412.

Esterbauer, H., Dieber, R. M., Striegl, G., & Waeg, G. (1991). Role of Vitamin-E in preventing the oxidation of low density lipoprotein. *American Journal of Clinical Nutrition, 53*, 314-321.

Fijesh, Vijayan P. Study of anticancer activity of selected medicinal plants with special reference to Hibiscus furcatus and Ophiorrhiza species. (Doctoral dissertation, Amala cancer research centre, Mahatma Gandhi University): 150-155.

Finar, I. L. (1973). Organic chemistry. Longman Singapore Publisher Ltd.

Foyer, C. H., & Halliwell, B. (1976). The presence of glutathione and glutathione reductase in chloroplasts: A proposed role in ascorbic acid metabolism. *Planta, 133* (1), 21-25.

Ghaly, A. E., & Alkoaik, F. N. (2010). Extraction of protein from common plant leaves for use as human food. *American Journal of Applied Sciences*, 7(3), 331.

Gong, H., Zhu, X., Chen, K., Wang, S., & Zhang, C. (2005). Silicon alleviates oxidative damage of wheat plants in pots under drought. *Plant Science, 169*, 313-321.

Guil, J. L., Rodriguez-Garcia, I., & Torija, E. (1997). Nutrition and toxic factors in selected wild edible plants. *Plant Foods for Human Nutrition*, 51, 99-107.

Harborne, J. B. (1977). "Phenolic glycisides and their natural distribution in the biochemistry of phenolic compounds", Academic Press, New York, London. 152-162.

Hedge, J. E., & Hofreiter, B. T. (1962). In R. L. Whistler & J. N. BeMiller (Eds.), Methods in carbohydrate chemistry, Academic Press. 17, 420.

Jagessar, R. C. (2017). Phytochemical screening and chromatographic profile of the ethanolic and aqueous extract of *Passiflora edulis* and *Vicia faba* L. (Fabaceae). *Journal of Pharmacognosy and Phytochemistry*, 6(6), 1714-1721.

Jansman, A. J. M. (1993). Tannins in feedstuffs for simple-stomached animals. *Nutrition Research Reviews*, 6(2), 209-236.

Kumar, R. (1983). Antinutritional factor, the potential risk of toxicity and methods to alleviate them. In Legume trees and other fodder trees as protein sources for livestock. Food and agricultural organization, 145-160.

Lichtenthaler, H. K., & Wellburn, A. R. (1983). Determinations of total carotenoids and chlorophylls a and b of leaf extracts in different solvents. *Biochemical Society Transactions*, 11(5), 591-592.

Lowry, O. H., Rosebrough, N. J., Farr, A. L., & Randall, R. J. (1951). Protein measurement with Folin's phenol reagent. *Journal of Biological Chemistry, 193*, 265-275.

Magaldi, S., Mata-Essayag, S. & Hartung de Capriles, C. (2004). Well diffusion for antifungal susceptibility testing. *International Journal of Infectious Diseases*, 8, 39-45.

Makkar, H. P. S., Blümmel, M., Borowy, N. K., & Becker, K. (1995). Gravimetric determination of tannins and their correlations with chemical and protein precipitation methods. *Journal of the Science of Food and Agriculture*, 69(3), 329-332.

Manthey, F. A., & Xu, Y. (2009). Glycobiology of foods: Food carbohydrates-Occurrence, production, food uses, and healthful properties. In *Advances in food biochemistry*, 1-524

Mayer, U., Treutter, D., Santos-Buelga, C., Bauer, H., & Feucht, W. (1995). Developmental changes in phenol concentrations of 'Golden Delicious' apple fruits and leaves. *Phytochemistry, 38*, 1151-1156.

McKersie, B. D., & Brown, D. C. (1996). Somatic embryogenesis and artificial seeds in forage legumes. *Seed Science Research*, 6(3), 109-126.

Miller, G. L. (1959). Use of dinitrosalicylic acid reagent for determination of reducing sugar. *Analytical Chemistry*, 31(3), 426-428.

Mishra, V. K., Bacheti, R. K., & Husen, A. (2011). Medicinal uses of chlorophyll: A critical overview. *Chlorophyll: Structure, function and medicinal uses*, 177 -196.

Moore, S., & Stein, W. H. (1948). In S. P. Colowick & N. O. Kaplan (Eds.), Methods in Enzymology. Academic Press. 3, 468.

Murcia, M. A., Jimenez, A. M., & Martínez-Tome, M. (2001). Evaluation of the antioxidant properties of Mediterranean and tropical fruits compared with common food additives. *Journal of Food Protection*, 64, 2037-2046.

National Institutes of Health. (2021). *Vitamin-A - Fact Sheet for Health Professionals*.

Pradeesh, S., & Swapna, T. S. (2018). *In vitro studies and phytochemical evaluation of Bidens biternata*. LAP Lambert Academic Publishing. 64-105.

Prakash, D., Gupta, C., & Sharma, G. (2012). Importance of phytochemicals in nutraceuticals. *Journal of Chinese Medicine Research and Development*, 1(3), 70-78.

Price, A., Lucas, P. W., & Lea, P. J. (1990). Age dependent damage and glutathione metabolism in ozone fumigated barley: a leaf section approach. *Journal of Experimental Botany*, 41(10), 1309-1317.

Putter, J. (1974). In H. U. Bergmeyer (Ed.), Methods of enzymatic analysis. Academic Press. 685-690.

Roberts, M. F. (1998). Alkaloids: biochemistry, ecology, and medicinal applications. Plenum Press, New York, USA. 1-7.

Rosenberg, H. R. (1992). Chemistry and physiology of vitamins. Interscience Publishers Inc. 452–453.

Schanderi, S. H. (1970). Methods in Food Analysis, 2nd ed., Josely, M. A., Ed., Academic Press, London. 709.

Shingo, Y., Sakurada, S., & Nagumo, M. (1994). Role of intracellular SOD in protecting human leukemic and cancer cells against superoxide and radiation. *Free Radical Biology and Medicine*, 17(5), 389-395.

Szabados, L. and Savoure, Arnould. (2010). Proline: a multifunctional amino acid. *Trends in Plant Science*, 15 (2): 89-97.

Thayumanavan, B., & Sadasivam, S. (1984). Physicochemical basis for the preferential uses of certain rice varieties. *Quality Plant Foods for Human Nutrition*, 34(3), 253-259.

Traber, M. G., & Atkinson, J. (2007). Vitamin-E, antioxidant and nothing more. *Free Radical Biology and Medicine*, 43(1), 4-15.

Valgas, C., De Souza, S. M., Smânia, E. F. A., & Smânia, A. (2007). Screening methods to determine antibacterial activity of natural products. *Brazilian Journal of Microbiology*, 38, 369-380.

Wheeler, E. L., & Ferrel, R. E. (1971). A method of phytic acid determination in wheat and wheat fractions. *Cereal Chemistry*, 48(3), 312-316.

Whitney, E., Rolfes, S. R., Crowe, T., & Walsh, A. (2022). Understanding Nutritio. Cengage AU. 1-840

Witham, F. H., Blaydes, D. F., & Devlin, R. M. (1971). *Experiments in Plant Physiology*. Van Nostrand Reinhold Company. New York. 55-56.

Yadav, R. N. S., & Agarwala, M. (2011). Phytochemical analysis of some medicinal plants. *Journal of Phytology,* 3(12), 10-14.

Yoruk, R., & Marshall, M. R. (2003). Physicochemical properties and function of plant polyphenol oxidase: A review. *Journal of Food Biochemistry*, 27(5), 361-422.

Zakaria, H., Simpson, K., Brown, P. R., & Krotulovic, A. (1979). Use of reversed phase HPLC analysis for the determination of provitamin-A carotenes in tomatoes. *Journal of Chromatography, 176*, 109-117.

Zhang, J., & Kirkham, M. B. (1996). Enzymatic response of the ascorbate-glutathione cycle to drought in sorghum and sunflower plants. *Plant Science*, 113(2), 139-147.