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Effect of Petroleum Products and Calcium Carbide on Lipid Peroxidation and Ascorbic Acid Content of Ripened Soursop (Annona Muricata L.) Fruits

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Abstract **- The ripening agents and environmental contaminants that soursop (Annona muricata L.) is exposed to can affect its post-harvest quality, altering its nutritional and biochemical physiognomies. This study evaluated the effects of calcium carbide and two petroleum products (kerosene and diesel) on the quantity of ascorbic acid and lipid peroxidation in ripened soursop fruits. Four treatment groups were used in a fully randomized design: diesel, kerosene, calcium carbide, and control (natural ripening), each of which was replicated three times. Ascorbic acid was measured using 2,6-dichlorophenolindophenol titrimetry, and lipid peroxidation was measured as malondialdehyde (MDA) via the thiobarbituric acid reactive substances assay.In contrast to the control (0.60 ± 0.18 mg/g fwt), kerosene and calcium carbide significantly increased lipid peroxidation (17.11 ± 1.56 and 15.47 ± 4.12 mg/g fwt, respectively), whereas diesel formed an intermediate value. Ascorbic acid levels were lowest in fruits treated with calcium carbide (11.65 ± 4.45 mg/g) and highest in the control group (28.70 ± 3.09 mg/g).Thus, exposure to calcium carbide and petroleum compounds will increase oxidative stress and reduce antioxidant stores. Fruit quality, nutritional value, and consumer safety were all favored by natural ripening, which best maintained membrane stability and vitamin C.**

Keywords: Lipid peroxidation, Ascorbic acid, Soursop, Annona muricata, Calcium carbide, Kerosene, Diesel, Oxidative stress.

I. INTRODUCTION

The tropical fruit soursop (Annona muricata L.), occasionally referred to as guanabana or graviola, is valued for its nutritional, therapeutic, and commercial significance. Rich in vitamins, minerals, and bioactive substances including acetogenins, phenolics, and flavonoids. it is extensively grown throughout Nigeria, especially in the humid southern areas like Lagos (Igiehon *et al.*, 2026). The fruit experiences well-documented physiological changes during post-harvest storage (Vasconcelos *et al.*, 2026; Zaini *et al.*, 2026), and its seed oil and defatted flour both add functional and nutritional value (Ekpenyobhiele et al., 2026).

The process of fruit ripening is a genetically orchestrated and intricately coordinated physiological event that involves significant modifications in colour, texture, flavour, aroma, and nutritional content. At the biochemical level, it is characterized by an increase in respiration rates in climacteric fruits, the biosynthesis of ethylene, degradation of cell walls, pigment changes, and the generation of volatile compounds(Negi *et al.*, 2026; Sahoo *et al.*, 2026; M. J *et al.*, 2025). These biochemical processes are frequently associated with heightened oxidative stress resulting from increased metabolic activity and the accumulation of reactive oxygen species (ROS). Plants respond to this stress through the action of enzymatic antioxidants such as peroxidase, catalase, and superoxide dismutase, as well as non-enzymatic antioxidants like ascorbate and glutathione(Yu *et al.*, 2026; Rao *et al.*, 2025; Sharma *et al.*, 2022). Nonetheless, under external stress conditions, including exposure to xenobiotic agents, this balance can be disrupted, leading to oxidative damage. Lipid peroxidation, which refers to the oxidative breakdown of polyunsaturated fatty acids within cell membranes, serves as a key indicator of cellular damage. This process is initiated by the attack of reactive oxygen species (ROS) on lipid bilayers and progresses through a free-radical chain reaction that produces reactive aldehydes, including malondialdehyde (MDA) and 4-hydroxynonenal. These secondary metabolites are cytotoxic in nature, capable of forming adducts with proteins and impairing cellular functions (Abeokuta *et al.*, 2026; Chaudhari *et al.*, 2026; Ha *et al.*, 2026). In the context

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of post-harvest physiology, the degree of lipid peroxidation is associated with the deterioration of membrane integrity, increased electrolyte leakage, hastened senescence, and diminished marketability.

In oil-producing regions like Nigeria, petroleum products—such as crude oil, diesel, kerosene, and petroleum ether—are widespread environmental pollutants. They contaminate agricultural soils and water, adversely affecting plant physiology (J. Abeokuta, 2026; George *et al.*, 2023; Sam *et al.*, 2023). When plants and fruits are exposed to petroleum hydrocarbons, it frequently results in oxidative stress, which increases lipid peroxidation and modifies antioxidant activity. In non-formal settings, kerosene, petrol fractions, and similar solvents are sometimes employed to speed up ripening, although scientific studies more frequently connect them with laboratory lipid extraction rather than with intentional ripening. When quick ripening is required after harvesting, various agents are applied to satisfy market needs; ethylene and ethephon are conventional choices, yet unregulated practices may sometimes utilize hazardous substances, particularly calcium carbide, which releases acetylene that mimics ethylene and accelerates the ripening process (Momtaz *et al.*, 2026; Vidhya *et al.*, 2025; Igiebor *et al.*, 2023). Such practices raise significant concerns regarding food safety and quality that are well-documented (Osei Tutu *et al.*, 2026; Mkhari *et al.*, 2025; Setiarto *et al.*, 2025).Among the various nutrients found in fruits, ascorbic acid (vitamin C) stands out as one of the most crucial water-soluble vitamins. It plays a significant role in collagen synthesis, wound healing, immune system function, and offers protection against oxidative stress (Bishop *et al.*, 2026; Omar, 2026; Alberts *et al.*, 2025). A decrease in the ascorbic acid levels of fruits that have been exposed to petroleum products would diminish their nutritional value and present risks to consumers. Furthermore, both pre-harvest and post-harvest factors have a substantial impact on the retention of this vitamin (Abeysuriya *et al.*, 2024). Considering the perishable nature of such produce and the economic significance of maintaining post-harvest quality, it is essential to explore the effects of petroleum products on the ascorbic acid content of ripe soursop fruits during storage.

This research occupies a critical position at the convergence of post-harvest technology, food safety, and environmental biochemistry. It offers empirical, quantitative insights into the biochemical effects of utilizing petroleum products and calcium carbide for fruit ripening, with a particular emphasis on oxidative stress indicators. By investigating lipid peroxidation and ascorbic acid levels, this study aims to clarify the mechanisms by which these practices influence the quality and safety of fruits. The specific aims were: (i) to evaluate the level of lipid peroxidation in soursop fruits ripened naturally compared to those exposed to petroleum products and calcium carbide; and (ii) to analyze the impact of these substances on the nutritional and oxidative stability of the ripened fruits.

II. MATERIALS AND METHODS

Materials and Reagents

The study utilized fresh, mature soursop fruits (Annona muricata L.), calcium carbide, dual-purpose kerosene, automotive gas oil (diesel), and distilled water. The analytical-grade reagents included thiobarbituric acid (TBA), trichloroacetic acid (TCA), hydrochloric acid, oxalic acid, 2,6-dichlorophenolindophenol (DCPIP), potassium phosphate buffer, sodium hydroxide, and acetic acid. Absorbance was measured using a UV-visible spectrophotometer, while the fruit masses were recorded with an analytical balance.

Sample collection and treatment

Soursop fruits that were fresh, mature, and unripe were sourced from Ozoro Market located in Ozoro, Delta State, Nigeria. The selection process ensured uniformity in size and maturity, as well as the absence of physical damage or disease. The fruits were then transported to the laboratory and divided into four groups. Three groups underwent separate treatments with kerosene, diesel, and calcium carbide under ambient conditions, while the fourth group was left untreated to serve as the control. All samples were maintained at room temperature for three days (72 hours), during which changes in color, texture, and ripeness were monitored. After the ripening period, both the treated and control samples were prepared for biochemical analysis and compared with the naturally ripened control.

Experimental design

A fully randomised design was adopted. The fruits were divided into four groups: Group A (control, not subjected to any agent); Group B (subjected to calcium carbide); Group C (subjected to kerosene vapour); and Group D (subjected to diesel vapour). Each treatment group included three replicates.

Determination of fruit weight loss

The initial and final masses of each fruit were measured with an analytical balance, and weight loss was calculated as:

$$\text{Weightless (\%)} = \frac{Wi - Wf}{Wi} \times 100$$

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where *Wi* is the mass before storage and *Wf* the mass after storage.

Determination of lipid peroxidation

Lipid peroxidation was quantified spectrophotometrically as malondialdehyde (MDA) using the thiobarbituric acid reactive substances (TBARS) method established by Ujihara *et al.* (2026). A sample of one gram of fruit pulp was homogenized in 10 mL of 0.1% trichloroacetic acid and subsequently centrifuged at 10,000 rpm for a duration of 10 minutes. Following this, one millilitre of the resulting supernatant was combined with 4 mL of TBA reagent, heated in a water bath at 95 °C for 30 minutes, and then rapidly cooled in an ice bath. The absorbance was measured at 532 nm and adjusted for non-specific absorbance at 600 nm. The MDA concentration was obtained from:

$$\text{MDA} = \frac{A532 - A600}{155000}$$

where 155,000 $M^{-1}cm^{-1}$ is the molar extinction coefficient of MDA. Higher MDA values indicate greater lipid peroxidation.

Determination of ascorbic acid content

Ascorbic acid concentration was assessed through the 2,6-dichlorophenolindophenol (DCPIP) titration method according to AOAC [30]. One gram of fruit pulp was blended with 100 mL of 0.4% oxalic acid and filtered. A 10 mL portion of the filtrate was titrated with standardized DCPIP until a faint pink color persisted for 15 seconds, and the amount of DCPIP consumed was recorded. Ascorbic acid content was calculated as:

$$\text{Ascorbic acid (mg/100g)} = \frac{I \times Lf \times Vt}{Va \times Ws} \times 100$$

where I is the titre value, Lf the dye factor, Vt the total volume, Va the aliquot volume and Ws the sample weight.

The data were reported as mean ± standard deviation and evaluated with the Statistical Package for the Social Sciences (SPSS) version 25.0. Variations among treatment groups were examined using one-way analysis of variance (ANOVA), and means were differentiated by the Duncan multiple range test. The level of significance was set at $P < 0.05$.

III. RESULTS AND DISCUSSION

Lipid peroxidation

Lipid peroxidation, expressed as malondialdehyde (MDA), is shown in Table 1. It is a commonly used indicator of plant tissue degradation caused by free radicals and oxidative membrane damage. The MDA values for the four treatments were as follows: Control (0.60 ± 0.18) < Diesel (5.60 ± 3.56) < Calcium carbide (15.47 ± 4.12) < Kerosene (17.11 ± 1.56) mg/g.

Table 1: Mean lipid peroxidation of soursop fruits ripened under different treatment conditions

Treatment	Lipid peroxidation, MDA (mg/g fwt)
Control	0.60 ± 0.18
Calcium carbide	15.47 ± 4.12
Kerosene	17.11 ± 1.56
Diesel	5.60 ± 3.56

Values are mean ± standard deviation of three replicates.

The control fruits had the lowest MDA concentration because they matured organically without the use of chemicals. The typical, physiologically controlled ripening process, in which endogenous antioxidant defenses (ascorbate, glutathione, superoxide dismutase, and catalase) control reactive oxygen species (ROS) and restrict membrane lipid oxidation, is reflected in this low baseline. The low number indicates that membrane integrity is mostly maintained in the absence of an external oxidative stressor, with just a slight increase in peroxidation linked to senescence. According to reports by Vijeev *et al.* (2026) that naturally ripened fruits had far lower MDA levels than their artificially ripened equivalents. The MDA levels in diesel-treated fruits were around nine times higher than in the control group, suggesting moderate oxidative damage. Diesel is a heavier, less volatile petroleum distillate; compared to lighter fractions, its vapor phase produces relatively less volatiles that imitate ethylene and reactive, low-molecular-weight hydrocarbons. As a result, ROS are induced more slowly and with less intensity, leading to intermediate lipid peroxidation. The wide standard deviation (± 3.56) indicates that the somewhat viscous, low-vapour-pressure fuel was either unevenly exposed or varied fruit-to-fruit penetration, which would result in inconsistent oxidative reactions across repeats. Nevertheless, the increase over control is in line with the overall finding that exposure to petroleum products upsets the pro-oxidant/antioxidant balance in plant tissue, encouraging membrane peroxidation.

While the MDA was increased by calcium carbide to almost 26 times the control value. Commercial-grade carbide is also tainted with arsenic and phosphorus (as arsine and phosphine), all of which are potent pro-oxidants. When calcium carbide comes into touch with moisture, it produces acetylene (C_2H_2), which mimics ethylene and causes rapid, premature ripening. Membrane polyunsaturated fatty acids undergo extensive peroxidation and substantial MDA buildup as a result of the combined action of an accelerated burst of

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ROS that overwhelms the antioxidant system. This outcome is consistent with studies of Mursal *et al.* (2025) and Borgonovi *et al.* (2023) that show significantly increased MDA and oxidative damage in carbide-ripened fruits like mango, banana, and tomato. These studies identify calcium carbide as a strong inducer of lipid peroxidation and a known health and quality hazard.Among the treatments, kerosene produced the greatest MDA content, at about 29 times the control level and marginally above the calcium carbide value as similar to the work conducted by Hafez *et al.* (2024). Kerosene is a light-to-middle petroleum distillate containing volatile aromatic and aliphatic hydrocarbons that evaporate readily under ambient conditions. This exposes fruit tissue to a sustained, concentrated mixture of reactive vapours capable of penetrating the tissue and reacting with membrane lipids. Such reactions generate lipid radicals and maintain chain-propagated peroxidation. The comparatively small standard deviation (± 1.56) points to uniform, effective vapour exposure across replicates, consistent with the compound's high volatility. The slightly higher value relative to calcium carbide indicates that persistent aromatic-hydrocarbon exposure may produce a greater oxidative burden than the acetylene/arsenic route. These findings accord with reports linking kerosene and other light petroleum products to marked oxidative stress and membrane injury in plant tissues.

Ascorbic acid content

Table 2 summarizes the mean ascorbic acid levels in the fruits. The control group recorded the highest value, 28.70 ± 3.09 mg/g, whereas calcium carbide-treated fruits had the lowest value, 11.65 ± 4.45 mg/g. Kerosene- and diesel-treated fruits exhibited intermediate levels relative to the control and calcium carbide treatments.

Table 2: Mean ascorbic acid content of soursop fruits ripened under different treatment conditions

Treatment	Ascorbic acid (mg/g)
Control	28.70 ± 3.09
Calcium carbide	11.65 ± 4.45

Values are mean ± standard deviation of three replicates.

Ascorbic acid is an essential antioxidant and an important indicator of nutritional quality, protecting plant tissues from oxidative damage by neutralizing free radicals (Rao *et al.*, 2025; Ali *et al.*, 2024; Wu *et al.*, 2024).The elevated levels observed in the control group suggest that natural ripening effectively maintained the antioxidant properties and nutritional integrity of the fruit. The higher levels measured in the control group indicate that natural ripening preserved the fruit's antioxidant properties and nutritional quality. The substantial reduction in ascorbic acid in treated fruits may reflect increased oxidative stress: as reactive oxygen species (ROS) accumulate during chemically induced ripening, ascorbic acid is consumed to neutralize them, depleting vitamin C reserves. This decline may also result from elevated respiration rates during rapid ripening, which promote the oxidation of ascorbic acid to dehydroascorbic acid and other degradation products (Ojarikre *et al.*, 2025; Wei *et al.*, 2025). These results are consistent with studies reporting reduced vitamin C levels in fruits exposed to artificial ripening agents and petroleum-derived contaminants (Nagaraja *et al.*, 2026; Pereira *et al.*, 2023; Wang *et al.*, 2023).

IV. CONCLUSION

Ripened soursop fruits exposed to calcium carbide, kerosene, and diesel showed significantly greater lipid peroxidation and lower ascorbic acid content, indicating heightened oxidative stress, compromised membranes, and weakened antioxidant capacity. Calcium carbide caused the greatest deterioration in nutritional quality, followed by kerosene and then diesel. Natural ripening methods provided the best preservation of membrane integrity and vitamin C levels. The inverse correlation between lipid peroxidation and ascorbic acid further suggests that oxidative stress associated with these agents promotes nutrient breakdown and fruit deterioration. Therefore, fruit ripening and storage practices should reduce exposure to petroleum-derived substances and chemical ripening agents to maintain quality and nutritional value while supporting consumersafety.

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DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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