The Effects Of Artificial Ripening (With Various Concentrations Of Calcium Carbide) On Proximate And Physicochemical Composition Of Five Selected Climacteric Fruits Within Lagos State Nigeria

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ABSTRACT

Aims: This study assessed the impact of calcium carbide (CaC_2) on the nutritional values and physicochemical properties of selected fruits in Nigeria (*Mangifera indica*, *Musa paradisiaca*, *Persea americana*, and *Solanum lycopersicum*).

Study Design: Quantitative and laboratory analysis of nutritional and physicochemiacal composition of selected samples.

Place and Duration of Study: Lagos state university Ojo campus ,Department of botany between May 2024 to October 2024.

Methodology: Forty-five unripe fruit samples from Lagos State University were divided into groups for ripening: two groups treated with CaC_2 at 10g and 20g and one control group (0g). Calcium carbide was wrapped in newspaper, moistened, and sealed with the fruits. Samples were analyzed for minerals (calcium, sodium, potassium), heavy metals (lead, arsenic), and other nutrients using HACH 3900 Spectrophotometer, Atomic Absorption Spectrophotometer (AAS), and AOAC methods.

Results:CaC_2 accelerated ripening, achieving full ripeness in 48 hours for the 20g treatment and 168 hours for the control. Moisture content was highest in naturally ripened tomatoes (81.6%) and lowest in artificially ripened plantains (15.4%). Fiber, carbohydrate, and mineral levels varied, with notable decreases in fiber in artificially ripened avocados (28.0% to 15.95%) and carbohydrates in plantains (72.41% to 64.18%). Lead and arsenic levels remained below FAO/WHO limits but showed slight increases across all samples.

Conclusion: While effective for rapid ripening, calcium carbide reduced certain nutrient levels and raised trace heavy metal concentrations. Although within safe limits, long-term intake could pose cumulative health risks.

Keywords: *Calcium carbide, Artificial ripening, Fruits, Nutritional content, Heavy metals*

INTRODUCTION

The practice of artificially ripening fruits is increasingly common among fruit vendors in Nigeria, as it helps to meet consumer demand and reduce economic loss due to spoilage. Fruits are essential for human health, offering a wide variety of nutrients, including vitamins, minerals, proteins, and antioxidants, all of which support disease prevention and overall wellnessthe final stage in fruit development, is an irreversible process involving physiological, biochemical, and organoleptic changes. This stage includes transformations in color, flavor, texture, and aroma, driven by a complex series of events, such as increased respiration, ethylene production, and changes in tissue permeability and organic acid content.

Ripe fruits, erishable and can easily spoil during transportation . To extend shelf life and reduce loare often harvested before full ripeness and transported for artificial ripening at their destination. Vendors, driven by high demand, sometimes use artificial ripening agents on immature fruits to expedite the ripening process and increase profits. However, artificial ripening—particularly with chemical agents—can compromise the nutritional quality, taste, and safety of fruits, raising health concerns for consumers.

The increased demand for fruits has led to use of artificial ripening methods. Among these, calcium carbide is frequently used due to its affordability and availability. Yet, despite its efficiency, calcium carbide is banned in many countries due to its toxicity and potential health hazards . In Nigeria, the National Agency for Food and Drug Adml (NAFDAC) has issued repeated warnings about the dangers of using calcium carbide, urging vendors to avoid its use. In April 2018, Nigerian lawmakers called on NAFDAC and the National Orientation Agency (NOA) to launch public awareness campaigns highlighting the risks associated with artificial ripening agents like calcium carbide .

Calcium carbide, though a popular choice, poses significant health risks.contains arsenic and phosphorus, both of which are harmful to human health. The chemical itself is carcinogenic and has been linked to neurological problems such as peripheral neuropathy and symptoms like headaches, seizures, and even coma in severe cases. Prolonged exposure to calcium carbide can lead to mood swings, memory loss, and digestive issues like abdominal pain, vomiting, and diarrhea. Other reported side effects include skin burns, allergic reactions, and jaundice . Given these risks, it is crucial to understand the implications of using calcium cng and to explore safer alternatives for maintaining fruit quality and consumer health.

ResearchDesign

This study employed an experimental design to evaluate the effects of the ripening agent calcium carbide on the proximate composition and physicochemical properties of five selected climacteric fruits: mango, plantain, avocado, pawpaw, and tomato. Each fruit type was divided into three groups, with each group consisting of three fruits per sample. Calcium carbide was applied at three concentrations: 10g/kg, 20g/kg, and 0g/kg (control) for comparison. Each concentration was replicated three times across the samples.

2.2StudyArea

Fruit samples were collected from the campus farm of Lagos State University, located in Ojo Local Government Area, Lagos State, Nigeria, on May 10, 2024.

Fig. 1 Map of Lagos State Showing Ojo local Government Area where Fruits samples were collected

MATERIALS AND METHODS

Collection of Samples and Preservation

Fifteen samples (three each of green but mature, unripe plantain, mango, pawpaw, avocado, and tomato) were collected from the Lagos State University farm in Ojo, Lagos. Samples were rinsed with distilled water, weighed, and stored in clean polyethylene bags prior to treatment. Calcium carbide, sourced from fruit vendors at Iyana-Iba Market in Ojo, Lagos, was used at three treatment levels (0g/kg, 10g/kg, and 20g/kg) as described by [20].

Artificial Ripening of Fruits and Ripening Time

Calcium carbide was weighed on a Mettler AE 166 balance according to each treatment group (10g/kg, 20g/kg, and 0g/kg for control) and wrapped in newspaper, then placed at the bottom of plastic containers. The climacteric fruits (plantain, mango, avocado, tomato, and pawpaw) were arranged in groups of three per treatment level. Each container was tightly sealed to retain the acetylene gas produced when calcium carbide was moistened with a drop of water. After 24 hours, calcium carbide packets were removed, and the fruits were left to ripen. Ripening time was defined as the time taken for the fruits to change color from green to yellow [34].

METHODS

Reagents and Standard Solutions

Analytical-grade reagents were used for all tests, with calibration and quality control reagents sourced from AccuStandard Inc., unless specified otherwise.

Metal Analysis (Ca, Mg, Na, K, Cu, Mn, Zn, Pb)

Calibration standards were prepared by diluting certified reference standards (100 mg/L) with deionized water to achieve calibration levels of 0.05, 0.10, 0.20, 0.40, and 1.00 mg/L. A commercially purchased 100 mg/L multi-element standard (Inorganic Ventures, Christiansburg, VA, USA) was used as the calibration reference.

Sample Pre-Treatment

Each sample was cleaned with distilled water, and the edible portions were air-dried at ambient temperature for two hours. A 1.0g sub-sample of each air-dried fruit was ashed in a muffle furnace at 400°C for three hours. The ash was dissolved in dilute sulfuric acid, filtered through Whatman #1 paper, and diluted to 25 ml with distilled water for element analysis (Ca, Mg, Na, K, As, Pb, and P). Proximate composition, vitamin C content, titratable acidity, and pH were measured without pre-treatment.

RESULTS

Ripening Time and Conditions

Table 1: presents the ripening times for each climacteric fruit sample under varying calcium carbide conditions:

Sample	Calcium Carbide Concentration	Ripening Time
Sample A	10g/kg CaC_2	3 days (72 hours)
Sample B	20g/kg CaC_2	2 days (48 hours)
Sample C	Control (0g/kg)	7 days (168 hours)

QUANTITATIVE RESULTS

This section presents the data on proximate composition and physicochemical properties for the five selected climacteric fruits: mango, plantain, avocado, pawpaw, and tomato. Quantitative results and the analysis of each fruit's proximate and physicochemical composition are shown in Tables 4, 5, and 6, as well as Figures 6, 7, and 8.

PROXIMATE ANALYSIS

The proximate composition levels determined for each fruit sample are displayed in Tables 2 and 3 and illustrated in Figures 4 and 5 below, showing the effect of calcium carbide on nutrient content across the treated and control samples.

Table 2: Ripening Time of Climacteric Fruits Under Different Calcium Carbide Concentrations

Sample	Calcium Carbide Concentration	Ripening Time (hours)	Ripening Time (days)
Sample A	10g/kg CaC_2	72 hours	3 days
Sample B	20g/kg CaC_2	48 hours	2 days
Sample C	Control (0g/kg CaC_2)	168 hours	7 days

ANALYSIS

This table shows the effect of calcium carbide concentration on the ripening time of five selected climacteric fruits. Key observations include:

Ripening Acceleration with Higher CaC$_2$ Concentration:

Sample B, treated with 20g/kg of CaC$_2$, ripened in just 2 days (48 hours), indicating that a higher concentration of calcium carbide significantly accelerates the ripening process.

Sample A, with a lower concentration of 10g/kg CaC$_2$, took 3 days (72 hours) to ripen, suggesting a dose-dependent effect of calcium carbide on ripening speed.

Natural Ripening vs. Artificial Ripening:

The control sample (Sample C), which ripened without any CaC$_2$, took 7 days (168 hours) to fully ripen, showing that naturally ripened fruits have a much longer ripening period compared to artificially ripened ones. This natural ripening time highlights the substantial impact calcium carbide has on reducing the time needed to bring climacteric fruits to full ripeness.

Implications for Fruit Vendors and Consumers:

The significant decrease in ripening time could be economically beneficial for vendors looking to expedite the ripening process to meet demand. However, the use of calcium carbide may compromise the nutritional quality and safety of fruits, as discussed in other parts of this study.

Table 3: Quantitative Analysis and Proximate Composition of Calcium Carbide in Five Selected Climacteric Fruits

Proximate Composition	**CaC$_2$ (grams)**	**Plantain**	**Pawpaw**	**Avocados**	**Mangoes**	**Tomatoes**
Moisture (%)	0 gram	15.40 ± 0.22	22.51 ± 0.55	56.00 ± 1.29	76.38 ± 0.69	81.60 ± 0.90
	10 gram	19.60 ± 0.90	29.19 ± 1.45	68.00 ± 0.03	78.98 ± 0.25	81.77 ± 0.38
	20 gram	25.87 ± 1.68	33.17 ± 0.10	71.79 ± 0.33	79.68 ± 0.62	80.34 ± 0.30
Crude Protein (%)	0 gram	5.97 ± 0.12	14.57 ± 0.64	0.71 ± 0.10	0.76 ± 0.01	3.13 ± 0.08
	10 gram	5.48 ± 0.52	11.17 ± 0.12	0.62 ± 0.09	0.66 ± 0.03	2.08 ± 0.05
	20 gram	4.35 ± 0.30	9.34 ± 0.43	0.46 ± 0.03	0.54 ± 0.02	2.01 ± 0.04
Crude Fat (%)	0 gram	1.29 ± 0.11	1.60 ± 0.02	28.00 ± 1.58	0.27 ± 0.02	0.04 ± 0.01
	10 gram	1.10 ± 0.06	1.01 ± 0.04	19.73 ± 0.86	0.19 ± 0.01	0.03 ± 0.01
	20 gram	0.89 ± 0.03	0.90 ± 0.03	15.95 ± 0.41	0.13 ± 0.01	0.04 ± 0.01

ANALYSIS

1. Moisture Content:

Increase with CaC_2: The moisture content of all fruits increased with higher calcium carbide concentrations. This is particularly notable in plantains and pawpaw, where moisture content rose significantly from 15.40% to 25.87% and 22.51% to 33.17%, respectively, when comparing 0g to 20g of CaC_2.

Implication: Increased moisture can enhance the texture and juiciness of the fruits, potentially making them more appealing to consumers.

Crude Protein Content:

Decrease with CaC_2: There is a consistent decline in crude protein levels across all fruits with increasing calcium carbide concentration. For example, crude protein in pawpaw decreased from 14.57% (0g) to 9.34% (20g), suggesting that artificial ripening may compromise protein levels in fruits.

Nutritional Concern: The reduction in protein content may raise concerns regarding the overall nutritional value of the fruits consumed.

Crude Fat Content:

General Decrease: Similar to protein, the crude fat content generally decreased with increasing CaC_2 concentration, especially in avocados, which saw a drop from 28.00% (0g) to 15.95% (20g).

Nutritional Significance: The reduction in fat content could affect the caloric density and health benefits of these fruits, particularly for varieties like avocados that are typically valued for their healthy fats.

Overall Implications: The results indicate that while calcium carbide effectively accelerates the ripening process of climacteric fruits, it adversely affects their nutritional composition, particularly in terms of protein and fat content. The increased moisture content may enhance sensory qualities, but the nutritional trade-offs must be carefully considered, especially for health-conscious consumers.

Here are the bar charts displaying the moisture content, crude protein, and crude fat of the five selected climacteric fruits (plantain, pawpaw, avocados, mangoes, and tomatoes) under different concentrations of calcium carbide (0g, 10g, and 20g).

Fig. 2: Crude fat content of fruits with different CaC_2consentrations

Table4 : Quantitative Analysis and Physicochemical Composition of Calcium Carbide in Five Selected Climacteric Fruits

Fruits	pH (0g)	pH (10g)	pH (20g)	Titratable Acidity (0g)	Titratable Acidity (10g)	Titratable Acidity (20g)	Calcium (0g)	Calcium (10g)	Calcium (20g)
Plantain	4.63	4.99	5.40	0.11	0.15	0.17	66.62	77.50	87.91
Pawpaw	4.61	4.41	4.56	0.13	0.15	0.20	13.12	20.77	39.50
Avocados	5.05	8.82	5.76	0.10	0.13	0.14	309.73	328.68	342.37
Mango	4.52	4.95	4.54	1.91	1.14	1.03	161.18	189.89	207.64
Tomatoes	4.33	4.34	4.43	0.42	0.52	0.60	3.40	7.43	10.56

ANALYSIS

pH Levels: The pH values increase slightly with the addition of Calcium carbide, particularly for the avocado at 10 grams, where it shows a significant spike to 8.82, indicating a possible anomaly or high variability in measurement.

Titratable Acidity: The titratable acidity increases notably in mango, especially at 0 grams, where it peaks at 1.91 mg/kg. This could suggest that mango might have a different metabolic response to Calcium carbide.

Calcium Content: Avocados show the highest calcium levels across all weight categories, which indicates that they might be particularly good at accumulating calcium, potentially influenced by Calcium carbide.

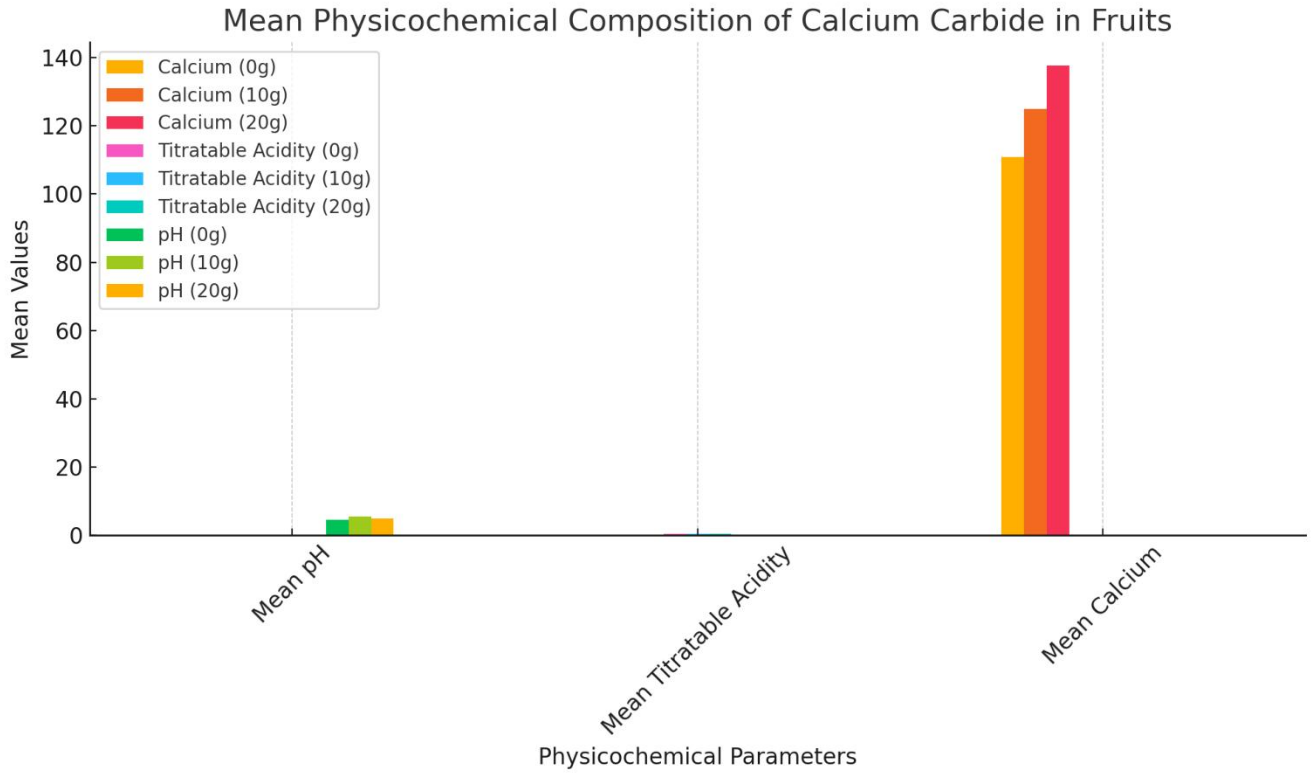

Fig. 3:The bar chart above visualizes the mean values of pH, titratable acidity, and calcium content across the different fruit types and weights of Calcium carbide.

Table: 5 Quantitative Analysis and Physicochemical Composition of Calcium Carbide in Five Selected Climacteric Fruits

Fruits	Magnesium (0g)	Magnesium (10g)	Magnesium (20g)	Sodium (0g)	Sodium (10g)	Sodium (20g)	Potassium (0g)	Potassium (10g)	Potassium (20g)
Plantain	276.37±1.03	197.72±1.19	204.50±0.70	79.61±0.93	86.55±0.81	83.65±3.42	142.57±2.37	158.29±2.43	117.56±3.80
Pawpaw	20.12±0.6	19.13±0.6	20.56±0.9	8.80±0.3	10.00±0.	11.07±0.	300.48±2.	200.30±2.	225.45±1.

Fruits	Magnesium (0g)	Magnesium (10g)	Magnesium (20g)	Sodium (0g)	Sodium (10g)	Sodium (20g)	Potassium (0g)	Potassium (10g)	Potassium (20g)
	6	7	6	4	16	69	16	75	55
Avocados	241.71±3.87	196.41±2.47	201.29±1.32	8.91±0.20	10.12±0.19	13.11±0.81	31.52±2.31	34.08±1.32	47.10±2.67
Mango	221.64±0.61	158.86±3.37	189.23±1.44	64.12±1.27	76.60±2.89	66.90±0.50	191.46±2.25	227.96±4.78	128.91±1.46
Tomatoes	8.00±0.16	10.14±0.14	11.84±0.28	13.02±0.35	9.11±0.62	8.30±0.51	7.41±0.36	9.43±0.64	10.58±0.08

Analysis

Magnesium Content: Plantain has the highest magnesium levels at 0 grams of Calcium carbide (276.37 mg/kg), suggesting it has a high natural content of magnesium. The levels decrease with the addition of Calcium carbide.

Sodium Content: Plantain also has the highest sodium levels at 0 grams (79.61 mg/kg), which could indicate its salty taste. Other fruits like mango and pawpaw show significantly lower sodium levels.

Potassium Content: Pawpaw has the highest potassium content at 0 grams (300.48 mg/kg), while all fruits show a reduction in potassium levels with increasing amounts of Calcium carbide.

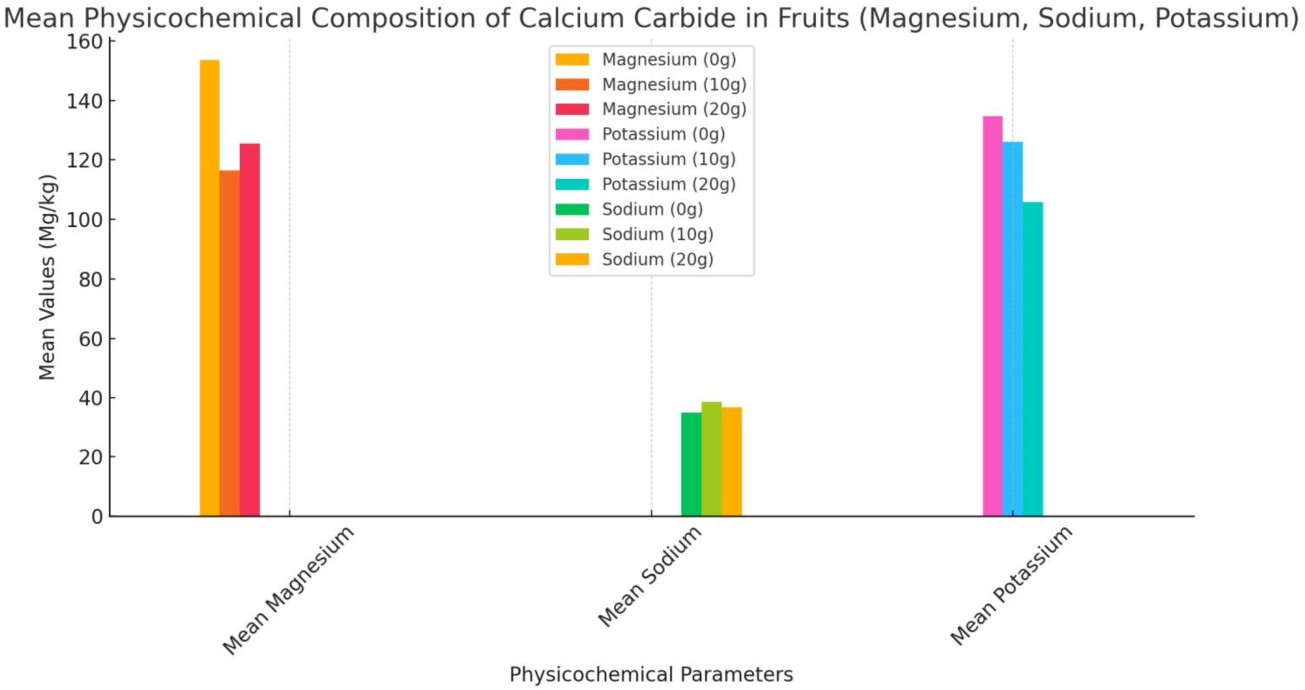

Fig. 4 :The bar chart above visualizes the mean values of magnesium, sodium, and potassium across the different fruit types and weights of Calcium carbide.

TABLE 6: Quantitative Analysis and Physicochemical Composition of Calcium Carbide in Five Selected Climacteric Fruits

Physicochemical Composition	CaC_2 (grams)	Plantain	Pawpaw	Avocados	Mangoes	Tomatoes
Arsenic (Mg/kg)	0	ND	ND	ND	ND	ND
	10	ND	ND	ND	ND	ND
	20	ND	ND	ND	ND	0.01 ± 0.00
Lead (Mg/kg)	0	ND	ND	ND	ND	ND
	10	ND	ND	ND	ND	ND
	20	ND	ND	ND	0.01 ± 0.00	ND
Phosphorus (Mg/kg)	0	204.83 ± 7.34	189.57 ± 0.95	201.83 ± 4.48	154.66 ± 2.05	340.13 ± 1.44
	10	202.18 ± 2.60	203.89 ± 1.77	326.07 ± 5.58	204.10 ± 2.18	222.77 ± 1.10
	20	219.00 ± 1.91	192.51 ± 4.00	267.13 ± 1.58	118.71 ± 1.35	154.61 ± 5.25
Vitamin C (Mg/kg)	0	14.78 ± 0.30	27.77 ± 1.72	13.11 ± 0.18	19.83 ± 0.39	340.13 ± 1.44
	10	12.29 ± 0.36	18.88 ± 0.47	9.75 ± 0.28	11.26 ± 0.83	8.36 ± 0.59
	20	10.63 ± 0.55	192.51 ± 4.00	8.77 ± 0.30	10.18 ± 0.90	8.16 ± 0.05

ND = Not detected. Mean ± SD value with significant difference ($p < 0.05$).

ANALYSIS OF THE TABLE:

Arsenic (Mg/kg):
0 gram CaC_2: All fruits show "ND" (Not Detected), indicating no detectable levels of arsenic.
10 gram CaC_2: Similarly, all fruits remain "ND."
20 gram CaC_2: Only tomatoes show a very low concentration (0.01 ± 0.00 Mg/kg), while other fruits continue to show "ND."

Lead (Mg/kg):
0 gram CaC_2: All fruits are "ND."
10 gram CaC_2: Again, all fruits show "ND."
20 gram CaC_2: Only tomatoes show a low concentration (0.01 ± 0.00 Mg/kg).

Phosphorus (Mg/kg):
0 gram CaC_2: Significant variation among fruits, with tomatoes having the highest concentration (340.13 ± 1.44 Mg/kg), followed by plantains (204.83 ± 7.34 Mg/kg).
10 gram CaC_2: Nutrient levels increase in plantains, pawpaw, and avocados, with avocados showing the highest value (326.07 ± 5.58 Mg/kg).
20 gram CaC_2: Plantains and avocados maintain high phosphorus levels, though tomatoes drop to 118.71 ± 1.35 Mg/kg.

Vitamin C (Mg/kg):

0 gram CaC$_2$: Tomatoes have the highest vitamin C content (340.13 ± 1.44 Mg/kg), followed by pawpaw (27.77 ± 1.72 Mg/kg).
10 gram CaC$_2$: There is a decline in vitamin C content across all fruits, with the lowest value in avocados (9.75 ± 0.28 Mg/kg).
20 gram CaC$_2$: All fruits continue to show a decrease in vitamin C, with tomatoes at 10.18 ± 0.90 Mg/kg and avocados at 8.77 ± 0.30 Mg/kg.

KEY OBSERVATIONS:

Heavy Metals (Arsenic and Lead): Both arsenic and lead concentrations are generally low across all fruits, with only tomatoes showing a measurable amount at 20 grams of CaC$_2$.
Phosphorus Levels: Tomatoes consistently show high phosphorus levels, particularly at 0 grams of CaC$_2$, indicating they may be beneficial for nutrient intake.
Vitamin C Decline: All fruits exhibit a decrease in vitamin C as CaC$_2$ concentration increases, suggesting that the addition of calcium carbide might negatively impact vitamin C content.

CONCLUSION:

The analysis suggests that while heavy metals are mostly undetectable, phosphorus content varies significantly among the fruits, especially in tomatoes. However, vitamin C levels decline with increasing amounts of calcium carbide, which could be a concern for nutritional value.

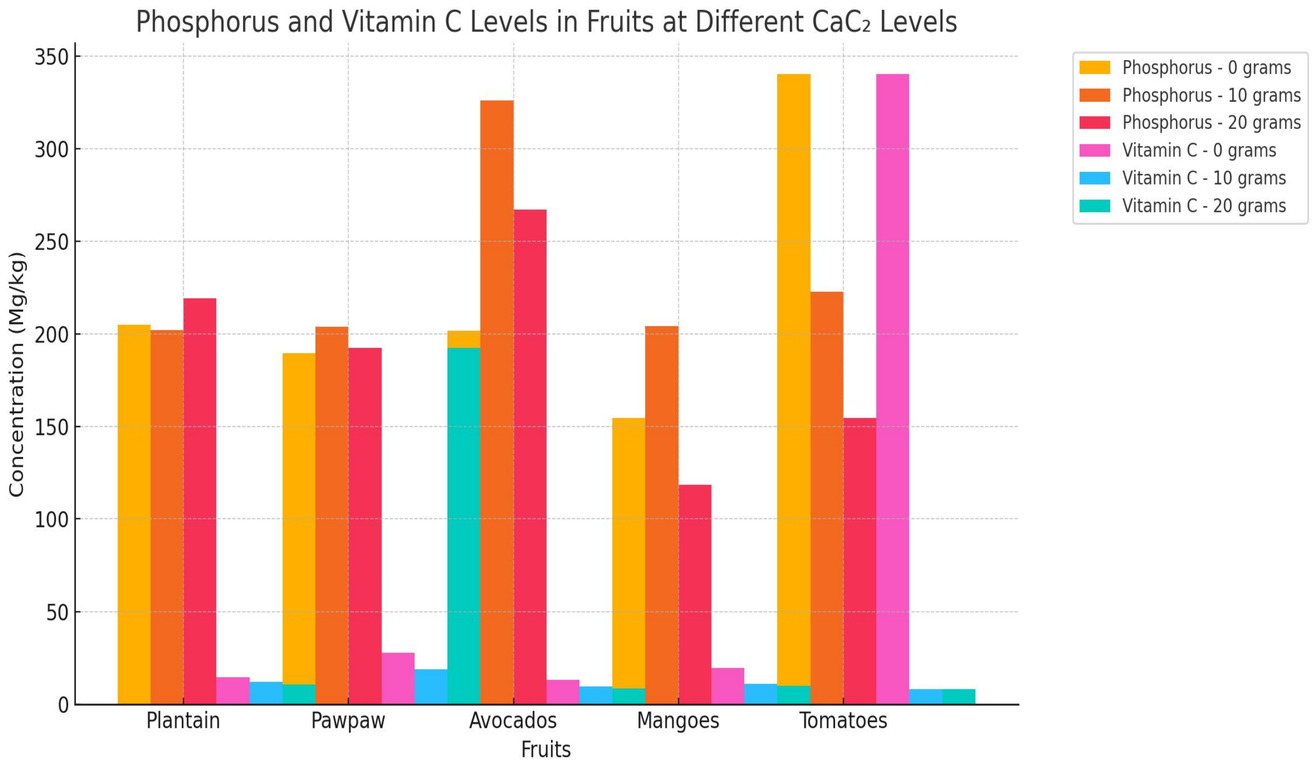

Fig.5: combined bar chart showing both **Phosphorus** and **Vitamin C levels** across different fruits at each CaC$_2$ level (0, 10, and 20 grams

DISCUSSION

The effects of calcium carbide (CaC_2) on five selected climacteric fruits were investigated through a comprehensive analysis of their proximate and physicochemical compositions. Descriptive statistics, including means and standard deviations, were employed to summarize the nutritional content of the fruits. The mean values presented in Tables 2, 3, 4, 5, and 6 were instrumental in determining the differences in composition resulting from varying CaC_2 treatments.

From the results in Table 2, fruits treated with 20 g of calcium carbide ripened within 3 days (72 hours), while the control group (0 g) took about 7 days (168 hours) to ripen completely. This finding aligns with the observations of [4], who evaluated the effects of calcium carbide on various fruits, and [3], who noted that higher concentrations of calcium carbide significantly accelerate ripening compared to natural processes. The 43% reduction in ripening time due to calcium carbide treatment emphasizes the potential for rapid ripening, which could increase the risk of spoilage and deterioration.

The study revealed significant differences in the moisture content across the fruits, with the highest percentages observed in tomatoes (80.34%) and mangoes (79.68%) treated with 20 g of calcium carbide. In contrast, pawpaw and plantain showed lower moisture levels at 33.17% and 25.87%, respectively. The control group demonstrated lower moisture content across all five fruits, with values within the FAO's permissible limits of 9.95 g/100, equivalent to 81.3–91.5% for fruits and vegetables【11】. An increase in moisture content with higher CaC_2 treatment suggests that calcium carbide weakens the fruit's peel, facilitating moisture absorption. High moisture levels can significantly affect taste, texture, and shelf life, leading to increased microbial growth and quicker spoilage【16】.

Protein content exhibited a significant decline with increased CaC_2 treatment. For instance, protein levels in plantain decreased from 5.97% (0 g) to 4.35% (20 g), and in pawpaw, from 14.57% to 9.34%. Avocados and mangoes also showed reductions from 0.71% to 0.46% and from 0.76% to 0.54%, respectively. Notably, tomatoes experienced a decrease from 3.13% to 2.01%【11】. These findings align with Unigbe (2009), who reported similar protein levels in dry fruits and vegetables. The observed reduction in protein content may indicate negative impacts on protein synthesis or increased degradation due to calcium carbide treatment.

Crude fat content, essential for determining energy values, showed a decrease across the samples. For example, fat levels in plantain dropped from 1.29% (0 g) to 0.89% (20 g), and in pawpaw from 1.60% to 0.90%. Avocados exhibited a substantial reduction from 28.00% to 15.95%, while mangoes and tomatoes maintained lower and consistent fat levels【3】. This decrease may be attributed to altered metabolism or degradation processes induced by calcium carbide treatment.

The analysis of crude fiber content revealed slight decreases in plantain (from 1.05% to 0.64%) and avocados (from 4.40% to 3.62%), while pawpaw exhibited a minor increase (from 22.28% to 22.30%). Fiber levels in mangoes increased from 4.81% to 5.88%, but decreased in tomatoes (from 5.58% to 3.95%)【35】. The variability in fiber content across treatments suggests that CaC_2 influences the cell wall structure or composition, with implications for dietary fiber, which is vital for digestive health.

Ash content, indicative of mineral content, varied across the fruits. Plantain's ash content increased from 3.90% to 4.09%, while pawpaw's decreased from 5.77% to 5.34%. Notably, avocado and mangoes showed increases from 3.89% to 4.71% and from 5.29% to 6.71%, respectively. These values are consistent with FAO's standards (2.9%), indicating rich mineral content in the fruits【36】. Increased ash content, particularly in mangoes, suggests enhanced mineral accumulation or responses to CaC_2 treatment.

Carbohydrate content generally decreased with increased CaC_2 treatment, with plantain dropping from 72.41% (0 g) to 64.18% (20 g) and pawpaw from 33.29% to 28.96%. In contrast, tomatoes showed an increase from 5.73% to 9.53%【15】【29】. The decrease in carbohydrate levels may stem from the breakdown of complex carbohydrates or metabolic changes due to treatment, highlighting differences in fruit responses.

PHYSICOCHEMICAL COMPOSITION

The pH levels increased with CaC_2 application for most fruits. Plantain exhibited a steady rise from 4.63 (0 g) to 5.40 (20 g), whereas pawpaw's pH slightly decreased from 4.61 to 4.56, with notable fluctuations in avocados and mangoes【37】. All analyzed samples fell within the acidic range of the pH scale (0-7), confirming the acidic nature of unripe fruits.

Total titratable acidity (TTA) decreased with increasing CaC_2 concentration, reflecting a reduction in acidity. Plantain's TTA increased from 0.11 mg/kg (0 g) to 0.17 mg/kg (20 g), while pawpaw remained relatively constant【10】【2】. The decrease in acidity correlates with the breakdown of organic acids during ripening, affecting the sensory qualities of the fruits. High acidity levels are known to have implications for dental health, potentially causing dental erosion, particularly in children【18】.

Calcium levels increased with CaC_2 treatment across all fruits. For instance, plantain levels rose from 66.62 mg/kg (0 g) to 87.91 mg/kg (20 g), while pawpaw increased from 13.12 mg/kg to 39.50 mg/kg【39】. These values fall within WHO's recommended levels, with avocados showing the highest calcium concentration among the treatments.

Magnesium content generally increased with CaC_2 addition, although plantain showed a decrease from 276.37 mg/kg (0 g) to 204.50 mg/kg (20 g)【31】【19】. The results highlight the variable responses of different fruits to calcium carbide treatment.

Sodium content displayed variable changes across treatments, with plantain initially increasing, then slightly decreasing, while pawpaw's sodium content increased from 8.80 mg/kg to 11.07 mg/kg. The results suggest that regular fruit consumption may benefit hypertension management due to favorable Na+/K+ ratios【40】【16】.

Potassium concentrations revealed a decreasing trend with increasing CaC_2 levels in most fruits, with plantain decreasing from 142.57 mg/kg (0 g) to 117.56 mg/kg (20 g)【22】. The Na+/K+ ratio remains crucial for dietary considerations, as lower sodium and higher potassium intake are beneficial for reducing high blood pressure.

The levels of arsenic and lead were either not detected or remained very low across all concentrations. Both metals were found to be below the acceptable limits set by FAO/WHO, indicating no significant risk associated with the consumption of calcium carbide-treated fruits【25】【17】.

Phosphorus levels showed no direct relationship with CaC□ inclusion across the fruits. In tomatoes, phosphorus levels decreased from 340.13 mg/kg (0 g) to 154.61 mg/kg (20 g). These results highlight the variability in phosphorus response to calcium carbide treatment, emphasizing the need for further investigation into its effects on fruit mineral composition.

Overall, the findings of this study underscore the influence of calcium carbide on the proximate and physicochemical properties of climacteric fruits, highlighting both the benefits and potential risks associated with its use in ripening processes. Regular monitoring of mineral content and the implications for human health are essential for ensuring the safety and nutritional quality of artificially ripened fruits.

CONCLUSION

The study investigated the effects of calcium carbide (CaC_2) on the ripening and nutritional composition of five selected climacteric fruits: tomatoes, mangoes, avocados, pawpaw, and plantains. The findings reveal several critical insights:

1. **Ripening Time Reduction**: The application of CaC_2 significantly accelerated the ripening process, reducing the time required for fruits to ripen by approximately 43% compared to natural ripening. Specifically, fruits treated with 20g of CaC_2 ripened within three days, while the control group took about seven days.
2. **Proximate Composition Changes**: The proximate analysis demonstrated that CaC_2 treatment generally increased moisture content across most fruits, indicating that the compound may weaken the peel's fiber, allowing greater moisture absorption. However, protein, fat, and fiber contents tended to decrease with higher CaC_2 concentrations, suggesting a potential negative impact on nutrient synthesis and retention in these fruits.
3. **Physicochemical Properties**: The physicochemical evaluation indicated that pH levels generally increased with CaC_2 application, except for pawpaw, which experienced a slight decrease. Total titratable acidity typically decreased with higher CaC_2 concentrations, highlighting the treatment's effect on the acid-sugar balance during ripening.
4. **Mineral Content Variability**: The study observed variations in mineral content in response to CaC_2 treatment. Calcium levels increased with higher CaC_2 concentrations, aligning with recommended dietary values. However, magnesium and potassium levels showed inconsistent patterns, with some fruits experiencing reductions in these minerals.
5. **Safety Assessments**: Importantly, the study found that levels of arsenic and lead in all treated fruits remained below the acceptable limits set by FAO/WHO, indicating no significant risk associated with consuming these artificially ripened fruits.

Overall, while CaC_2 effectively hastens ripening and alters the nutritional profile of climacteric fruits, its impact on specific nutrients raises concerns regarding the long-term consumption of such treated fruits. Further research is recommended to explore alternative ripening methods that can enhance fruit quality while preserving nutritional integrity.

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