



Science Forum (Journal of Pure and Applied Sciences)



Journal Homepage: <https://atbuscienceforum.com.ng/index.php/jpas>

Assessment of Nutritional Quality and Mineral Composition of Selected Artificially Ripened Fruits in Bauchi Metropolis, Nigeria

¹Dauda Sanda, ²Chioma Udoka Okeke, ³Chibuike Nwachukwu, ⁴Alabi Dorcas Ayandele

^{1,2}Department of Chemistry, Adamu Tafawa Balewa College of Education, Kangere Bauchi State, Nigeria

^{3,4}Department of Science Laboratory Technology, Federal Polytechnic Bauchi, Bauchi State, Nigeria

Abstract

This study evaluated the nutritional value and mineral composition of three commonly consumed fruits—orange (*Citrus sinensis*), banana (*Musa sapientum*), and pineapple (*Ananas comosus*)—artificially ripened with calcium carbide and sourced from local markets within Bauchi Metropolis, Nigeria. The study aimed to compare the proximate and mineral profiles of these fruits with those of their naturally ripened counterparts to assess the effects of chemical ripening on fruit quality. Standard analytical and spectrophotometric methods were employed for proximate composition, vitamin C estimation, and mineral determination. Results of the proximate analysis indicated that calcium carbide-induced ripening significantly increased the moisture (63.60–90.10%) and lipid contents (0.60–0.80%) relative to naturally ripened fruits (57.60–74.80% and 0.20–0.40%, respectively). Conversely, there was a marked reduction in crude ash (1.00–1.60%), crude protein (0.22–0.44%), crude fibre (7.60–11.60%), total carbohydrate (0.26–22.49%), and vitamin C (3.93–10.00 mg/g) compared with the naturally ripened samples (1.20–2.00%, 0.69–0.88%, 9.20–12.10%, 6.72–25.30%, and 6.35–16.50 mg/g, respectively). Mineral analysis further revealed that calcium (Ca) concentration was elevated in all calcium carbide-ripened fruits, while potassium (K) and magnesium (Mg) levels were significantly higher in naturally ripened fruits, indicating nutrient imbalance and mineral distortion due to the chemical ripening process. Overall, the findings demonstrate that artificial ripening with calcium carbide leads to nutrient depletion and compositional changes that compromise both the nutritional quality and safety of fruits. The study therefore underscores the potential health risks associated with the consumption of chemically ripened fruits and recommends stricter regulatory enforcement, continuous public health education, and promotion of safe, natural ripening techniques to safeguard consumer well-being.

Keywords

Calcium carbide,
Artificial ripening,
Nutritional quality,
Mineral composition,
Bauchi Metropolis,
Public health

ISSN 1119-4618



1119 4618

JPAS



— Faculty of Science, ATBU Bauchi —

Introduction

Fruits are delicious staple food eaten by humans due to its nutritional and mineral composition. They are rich in vitamins (A, C and E), proteins, minerals, carbohydrates, fats, dietary fibre and antioxidants essential for healthy living. The phenolic compounds present in fruits helps in the prevention of various diseases or ailments in humans (Dhembare, 2013; Adeyemi et al., 2018; Ekanem, et al., 2021). They are more enjoyable when ripe because ripening improves their flavor, makes them soft, more nutritious, making them more appealing and tastier compared to the unripe fruits (Paul and Barman, 2024). However, the natural process of ripening of fruits usually takes several days and, in most cases, may not produce a uniform peel colour that is appealing to the consumer.

Over ripening and damage of natural ripened fruits due to transportation issues have had a negative impact on the marketing and profitability of fruit business. To therefore meet the increased demand for ripe and attractive fruits by customers in marketplaces and the desire to overcome the limitations of natural ripening process, many fruit sellers have resorted to the use of artificial ripening agents ensure steady supply of fresh fruits and reduce economic loss, while meeting consumers demands, (Nwankwo et al., 2021; Islam et al., 2022).

A number of artificial ripening agents are therefore used by fruit vendors in markets across many developing countries. These include but not limited to calcium carbide, ethylene glycol, ethanol, methanol and ethephon (Hassan et al., 2019; Salisu et al., 2016; Maduwanthi and Marapana, 2021). Numerous studies have shown that artificially ripening of fruits have negative effects on

the quality and nutritional benefits of fruits, resulting in essential nutrient (minerals composition and antioxidants) deficiencies, which impact the health of consumers (Nura et al., 2018; Olubiyo et al., 2023). Calcium carbide is the most frequently used ripening agent in Nigeria due to its inexpensiveness, effectiveness and availability in various local markets (Asif, 2012; Chandel et al., 2018).

Many countries, including Nigeria have banned its use due to its carcinogenic properties, its adverse effect on the quality of fruits and other harmful health risks it could pose to unsuspecting consumers due to impurities like Arsenic (Ekanem et al., 2021; Oladipupo et al., 2022; Ain et al., 2023). Maduwanthi and Marapana, (2021) and Salisu et al., (2022) reported that artificial ripening significantly impacted the physicochemical properties, nutritional and sensory quality of banana fruit. In spite of these negative effects of artificially ripening fruits, the practice of using calcium carbide is become more endemic among fruits vendors in Nigeria. Considering the negative effect of induced fruit ripening on the nutritional values and the possible human health risks it could pose, it has become very imperative to carry out proximate analysis and elemental determination of artificially ripened fruits in Bauchi State.

Study Area

The study was carried out in Bauchi L.G.A of Bauchi state, North-East Nigeria. Fruit vendors within local markets within Bauchi Metropolis were consulted to assists in identifying mature unripe fruits sold in their shops.

Sample Collection and Preparation

Freshly unripened green but mature pinapples, banana and oranges were procured from three

station markets in Bauchi metropolis in Bauchi state, Nigeria. Fruit vendors within local markets were consulted to assist in identifying mature unripe fruits sold in their shops. The purchased fruits were divided into two equal weighted treatment groups. Both groups of fruits were carefully cleaned and taken to the laboratory. One group of fruits were allowed to ripen naturally (NR) while the other group were artificially treated with 10g of Calcium carbide before ripening (AR). For the AR group, the whole fruits were placed in separate containers and the CaC_2 wrapped in a polythene bag was placed in the middle of the container and kept in a laboratory cupboard.

Both groups will be observed under similar environmental conditions and checked at intervals for signs of ripening (change of skin colour from green to yellow) (Olubiyo et al., 2022). The NR and AR fruits were then thoroughly washed with deionized water, peeled, cut into smaller slices with a plastic knife and oven dried at 70°C for 48 hours. The dried samples were then pulverised into powder using a mortar and pestle, sieved and stored in an airtight plastic container (Ain et al., 2023).

Proximate Analysis

Proximate analysis of the study fruits was carried out according to Adeyemi et al., (2018) and Olubuyi et al., (2022)

Determination of Moisture Content

3g of each of the powdered samples of the fruits was weighed into a dry platinum dish crucible and heated in an oven at 105°C for 3 hours till a constant weight is achieved. The % moisture content was then calculated using the formula:

$$\% \text{ Moisture Content} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where W_1 = initial weight of empty crucible,
 W_2 = weight of crucible + sample before drying,

W_3 = final weight of crucible + sample after drying.

Determination of Ash Content

For the ash content determination, 3g of each fruit sample weighed into a platinum dish was transferred into a muffle furnace to be burnt at 550°C for two hours until completely ashed. The dish was cooled in a desiccator and weighed. The ashing and weighing process continued until a constant weight is obtained. The percentage ash content was calculated thus:

$$\% \text{ Ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100 \text{ where:}$$

W_1 = weight of crucible, W_2 = weight of sample before ashing, W_3 = weight of crucible + ash

Determination of nitrogen and protein content

1g of each fruit sample was digested in 25 cm³ of conc. H_2SO_4 in a 250cm³ conical flask. The total organic nitrogen after digestion converted into ammonium sulphate by diluting the sample solution was transferred into a 100cm³ volumetric flask with distilled water up to the mark. 25cm³ of 2% boric acid was transferred into a 250 cm³ conical flask, followed by two drops of phenolphthalein indicator. The content in the conical flask was then placed under a condenser with the tip completely immersed in the solution. 10cm³ of the digested sample solution and 18 cm³ of 40 % NaOH was reacted to release ammonia, which distilled into the boric acid. The borate ions formed were then titrated against 0.1M HCl using phenolphthalein indicator to detect a colourless end point (colourless). Percentage total nitrogen representing the amount of crude protein in fruit samples is estimated as follows:

$$\%N = \frac{(V_a - V_b) \times M_a \times M_n}{1L \times W_s} \times 100$$

Where: V_a = volume in mL of standard acid used in titration, V_b = volume in mL of standard acid used in blank titration, M_a = Molarity of acid (HCl), W_s = weight in gram of sample, M_n = Molar mass of Nitrogen= 14.007 g/mol. The protein content of the fruits was calculated from the formula below: % protein = F × % total nitrogen, where F is the conversion factor.

Determination of fibre Content

2g of each fruit sample was placed in a 100cm³ Kjeldahl flask and 50cm³ of H₂SO₄ was added and left for few minutes before slightly warming. After decanting the upper layer of the mixture when settled, 50cm³ of NaOH was added to the residue and boiled on a heating mantle for 30mins at 30°C. After several decantations with addition of water, the final residue was filtered and dried in an oven at 100°C. the dried residue will be weighed and % crude fibre content will be calculated using the formula:

$$\% \text{ Crude fibre content} = \frac{\text{Loss in weight after ashing}}{\text{Weight of sample before ashing}} \times 100$$

Determination of crude Lipid

3g of each of the samples was weighed into a beaker, enclosed with clean white handkerchief and placed in 50ml of n-hexane for extraction. The filtrate, after extraction, was placed in a weighed beaker and the solvent was allowed to evaporate. A constant weight of the beaker and the fat was obtained and recorded. The percentage crude lipid is calculated using the formula below:

$$\% \text{ Crude Fat} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

Determination of total Carbohydrate Content

The carbohydrate content of the fruit samples was determined by subtracting the total percentage compositions of moisture, fibre, protein, protein, lipid, ash contents and protein, lipid from 100.

$$\% \text{ Total Carbohydrate} = 100 - (\% \text{Moisture} + \% \text{Protein} + \% \text{Ash} + \% \text{Fibre} + \% \text{Lipid})$$

Determination of Vitamin C Content

Iodometric titration with reference to a standard ascorbic acid solution was used here to determine the vitamin C content of the fruits (Silva and Barbosa, 2009). The ascorbic acid in the fruit reacts with iodine to produce dehydroascorbic acid and iodide ions. The excess iodine in the reaction then reacts with the starch indicator to produce violet colour indicating the end point of the titration. The mass of vitamin C in sample is calculated using the formula below:

$$\text{Mass of vitamin C in sample} = \text{Mass of Standard Vit. C} \times \frac{\text{Titre value of Sample}}{\text{Titre value of Standard vitamin C}}$$

Mineral Determination

The determination of minerals was carried out using the methods described by Olubiyo et al. (2022). 1g of each pulverized fruit samples in a crucible was ignited in a muffle furnace at 550°C for 6 hours. The ash obtained was then dissolved in 10ml of 10% HNO₃ and heated for 20 minutes. The mixture was filtered through Whatman No 1 filter and the filtrate analyzed for mineral content using the Atomic Absorption Spectrophotometer (AAS).

Results and Discussion

Proximate Analysis of the Natural and Artificially Ripened Fruits

The results of the proximate analysis of the individual fruits are shown in figures 1- 3.

The proximate composition of the banana fruits (Fig. 1) revealed that there was a significant difference in the moisture, lipid, ash, fibre, carbohydrate, protein and Vit. C contents of the naturally ripened banana and Calcium carbide induced ripened banana. While the artificially ripened bananas had higher moisture content and lipid concentration, the naturally ripened fruit

had higher carbohydrate, lipid, ash, protein and vitamin C levels. Olubiyo et al. (2022) reported similar results for the moisture, lipid, ash, fibre and protein levels of both NR and AR Banana. In the banana fruits studied, carbide induced ripening significantly reduced the lipid, protein, carbohydrate and Vitamin C level of the fruit but increased the moisture.

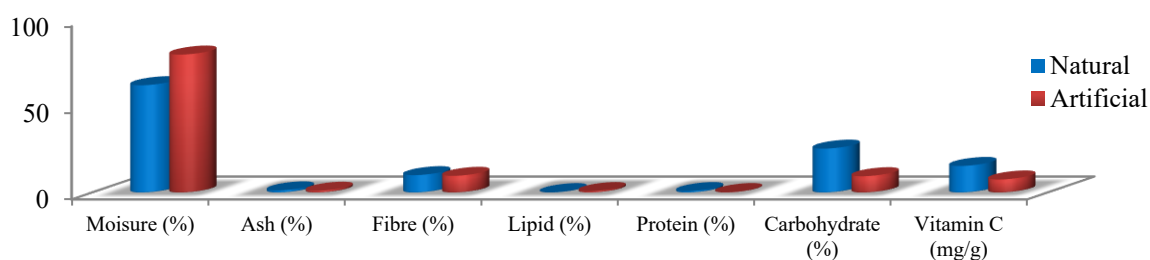


Figure 1: Proximate Composition of the Banana Fruits

Results obtained for both groups of pineapples studied indicated that the artificially ripened fruits contained higher moisture, lipid and carbohydrate levels while the natural ripe fruit had higher protein, fibre, ash and vitamin C levels.

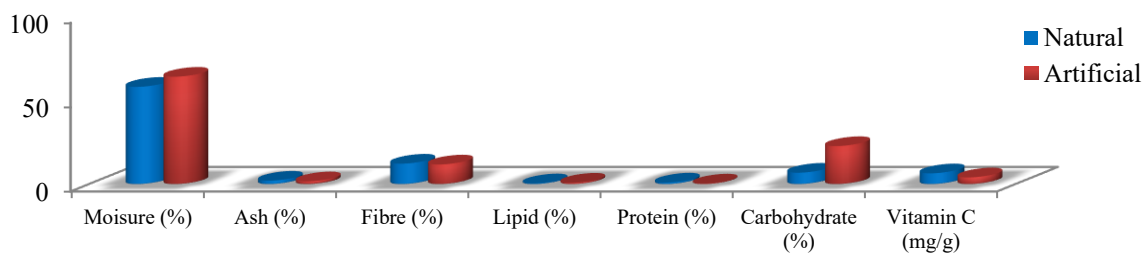


Figure 2: Proximate Composition of the Pineapple Fruits

Results of the analysis of the orange (Fig.3) showed that the carbide induced ripened fruits contained more moisture and lipid while the natural ripe fruit had higher protein, fibre, ash and carbohydrate levels. Olubiyo et al. (2022) reported higher

concentrations of carbohydrate and protein in naturally ripened oranges. From the study, artificial ripening of oranges reduced the lipid, protein, fibre, ash, carbohydrate and Vit. C content of the fruits while increasing the moisture content.

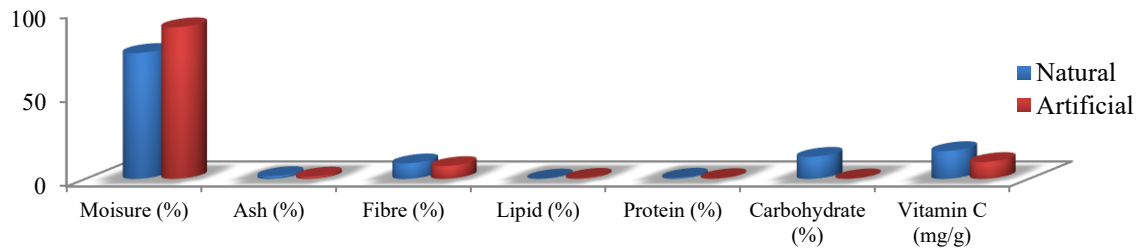


Figure 3: Proximate Composition of the Oranges Fruits

Table 1 shows the range of the parameters studied in the NR and AR fruits. From the results, fruits ripened naturally contain more protein (0.69-0.88%) compared to the artificially ripened ones (0.22-0.44%). This finding is consistent with those observed in Sogo-temi et al., (2014), Izundu et al., (2016) and Olubiyo et al., (2022). This decrease has been attributed to the decrease in the level of nitrogen when fruits are rapidly ripened. In line with this reason, Salisu et al., (2022) reported in his study that the % Nitrogen in naturally ripened Banana, Mango and Watermelon were higher compare to those ripened with calcium carbide.

The ranges of the % moisture contents in all the study fruits indicated that artificially ripened fruits have higher moisture contents. This increase may be as a result of induced ripening of the fruits (Ariyo et al., 2021). The increased moisture content can be attributed to the increase's absorption and retention of moisture in the fruits due to the weakening of the of the fruit skin. Secondly, during chemical reactions, moisture is generated; complex carbohydrates re broken down into simple sugars, which can also increase the moisture content of the artificially ripened fruit (Nuhu et al., 2020). The fruit moisture contents in this study agree with those reported in other studies indicating that induced ripening increases the level of moisture in fruits (Nuhu et al., 2020; Sojину

et al., 2021; Gunasekara et al., 2021; Ariyo et al., 2021; Okeke et al., 2022; Olubiyo et al., 2022). Moisture content indicates the freshness and potential shelf life of a given fruit, so an increase in moisture content could increase rate of microbial degradation, resulting in faster deterioration. Adeniyi et al., (2018) and Maduwanthi and Marapana, (2019) observed that calcium carbide induced ripened fruits have shorter shelf-life compared to the naturally ripened ones.

The higher carbohydrate concentrations (6.72 - 25.30%) found in this study for naturally ripened fruit, except for the pineapples, are in line with findings reported in Salisu et al. (2022) for naturally ripened Banana and mango fruits. Their study indicated that calcium carbide application reduces the carbohydrate content of fruits. Izundu et al. (2016) also stated that carbohydrate contents decreased in CaC_2 treated fruits than in the naturally ripened. Salisu et al. (2022) noted that the reduced carbohydrate content in AR fruits could be as a result of the accelerated action of the ripening agent on biochemical and physiological activities of fruits during the ripening process, resulting in the rapid conversion of starch to sugar. Artificially ripening of fruits in the current study generally reduced the fibre and lipid contents of fruits in comparison to naturally ripened fruits. Salisu et al. (2022) reported similar higher fibre content for naturally

ripened banana, mango and water melon fruits, and higher lipid content in artificial ripened Banana.

Table 1: Range of Parameters studied in the selected Fruits

Parameter	Moisture %	Protein %	Lipid %	Ash %	Fibre %	Carbohydrate %	Vit. C (mg/g)
NR Fruits	57.60-74.80	0.69-0.88	0.20-0.40	1.20-2.00	9.20-12.10	6.72 - 25.30	6.35-16.50
AR Fruits	63.60-90.10	0.22-0.44	0.60-0.80	1.00-1.60	7.60-11.60	0.26 - 22.49	3.93-10.00

NR - Naturally Ripened, AR - Artificially Ripened

Adeyemi et al., (2018) in their study observed that lipid content in the fruits increases with increased calcium carbide administration, and that the increased levels of lipids in the CaC₂ treated fruits could be due to the increase of lipid biosynthesis pathway through provision of precursor substrates obtained from the increased respiratory processes in Banana.

In this study, the % ash content was observed to be higher in all NR fruits (Banana, pineapples and oranges) compared to AR. Salisu et al. (2022) in their study observed that NR watermelon contains the highest ash content compared to other fruits studied. According to Gav et al., (2019), the level of ash content in a given fruit reflects the mineral content present in the fruit materials. This therefore implies that the NR fruits in this study could possibly be richer in mineral content compared to the artificially ripened ones.

The NR fruits were observed to contain more vitamin C compared to those ripened with Calcium carbide. Results from similar studies indicated the naturally ripened fruits (mangos, bananas, oranges) had more vitamin C content than the artificially ripened ones (Lestari 2013; Gbakon et al. 2018; Majagi and Jabannavar, 2019; Olubiyo et al. 2022; Salisu et al. 2022). Researchers suggest that the decrease in the vitamin C content may be as a result of the rapid action of Calcium carbide throughout the ripening phase.

Mineral Analysis of the Natural and Artificially Ripened Fruits

As shown in Figure 4, the concentrations of the minerals studied (mg/l) of the natural and artificially ripened bananas were in the orders Natural (0.004) > Artificial (0.003), Natural (0.009) << Artificial (0.016) and Natural (0.096) >>> Artificial (0.017) for potassium, calcium and magnesium respectively.

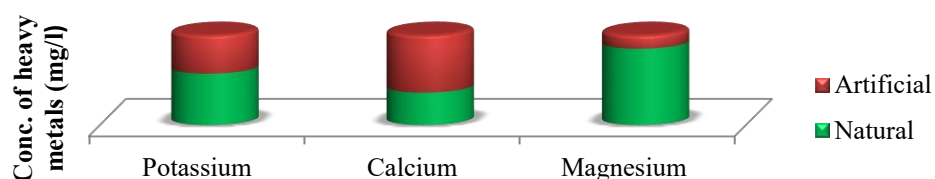


Figure 4a: Concentration of minerals (mg/l) of Banana Fruits

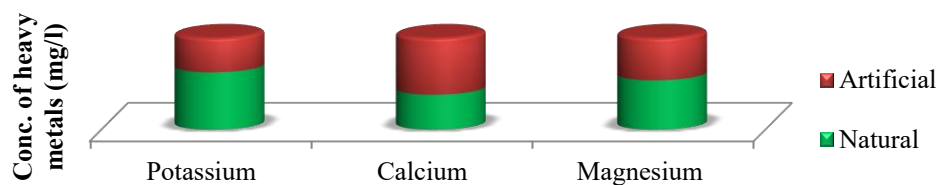


Figure 4b: Concentration of minerals (mg/l) of Orange Fruits

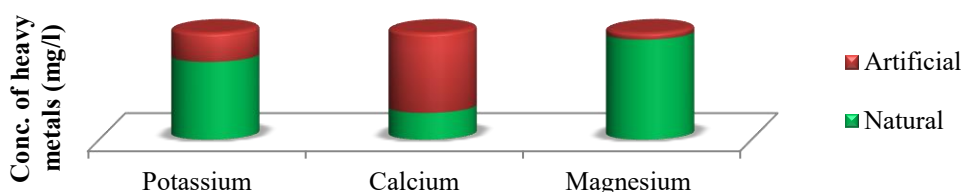


Figure 5: Concentration of minerals (mg/l) of Pineapple Fruits

For the orange fruits in Figure 5, the concentrations of the minerals studied (mg/l) were in the orders Natural (0.005)>>Artificial (0.003), Natural (0.008) <<<Artificial (0.013) and Natural (0.049)>Artificial (0.042) for the potassium, calcium and magnesium respectively. In figure 6, the order for the composition for potassium, calcium and magnesium of the pineapple fruits studied were Natural (0.008)>>>Artificial (0.003), Natural (0.006) <<< Artificial (0.018) and Natural (0.133)>>>Artificial (0.009) respectively. While the artificially ripening of fruits significantly increased the concentrations of calcium in all the fruits, it reduced the amounts of potassium and magnesium in artificially ripened fruits. The findings in this study is consistent with those of Bawa et al. (2020) and Oguntade and Fatumbi (2019). According to these studies, calcium levels in fruits generally increased after ripening with Calcium carbide. Higher levels of potassium and magnesium were observed for naturally ripened Banana,

pineapples and orange fruits in this study. The increased mineral level is a true reflection of the increased concentration of ash content of the studied natural fruits.

Conclusions

The result of the proximate and mineral content analysis of Calcium carbide induced ripened banana, pineapples and oranges shows that artificially ripening of these fruits significantly reduced protein, carbohydrate, ash, fibre, vitamin C and minerals contents like magnesium and potassium contents while increasing calcium, moisture and lipid levels of the fruits. The use of Calcium carbide as a ripening agent therefore affects the nutritional value and essential minerals in the study fruits.

Acknowledgement

The authors are grateful to TETFund for their support in ensuring that this study was carried out successfully

Reference

- Adeyemi, M. M., Bawa, M. H. and Muktar, B. (2018). Evaluation Of the Effect Of Calcium Carbide On Induce Ripening Of Banana, Pawpaw And Mango Cultivated Within Kaduna Metropolis, Nigeria. *Journal of Chemical Society of Nigeria*, 43(2): 108 -118.
- Ain, S.N.U., Abbasi, A. M., Ajab, H., Faridullah, Khan, S., Yaqub, A. (2023) Assessment of arsenic in Mangifera Indica (Mango) contaminated by artificial ripening agent: Target hazard quotient (THQ), health risk index (HRI) and estimated daily intake (EDI) *Food Chemistry Advances* 3 (2023) 100468
- Asif M (2012). Physico-chemical properties and toxic effect of fruit- ripening agent calcium carbide. *Annals of Tropical Medicine and Public Health*. 2012; 5:150-160.
- Ariyo O., Balogun B. and Solademi E.A. (2021). Effect of accelerated ripening agent on the nutrient and antinutrient composition of Banana. *Journal of Agriculture and Food Sciences*, 19(1): 63-77.
- Bawa, M.H., Eleke, P.N. and Abubakar, F. (2020). Effect of Calcium Carbide on Concentration of Trace Elements in Fruits Grown Within Kaduna Metropolis. *International Journal of Science and Engineering Applications*, 9(1):8-11.
- Chandel, R., Sharma, P. C., & Gupta, A. (2018). Method for detection and removal of arsenic residues in calcium carbide ripened mangoes. *Journal of Food Processing and Preservation*, 42(2), e13420.
- Dhembare A. J (2013). The bitter truth about fruits with reference to artificial ripeners. *Archives of Applied Science Research*.2013; 5(5):45-54.
- Ekanem, A. M., Sylvanus, W. N., Asanana, Q. E., Akpabio, I. I., Clement, E. I., Okpara, C. K., Okon, B. E., George, K. E. (2021). Fruit Ripening Methods and Knowledge of Health Effect of Use of Calcium Carbide in Ripening Fruits among Fruit Sellers in Uyo, Nigeria. *Journal of Advances in Medicine and Medical Research* 33(21): 72-83.
- Gav, B. L., Anyanwu, S. N., Oloruntoba, S.O. and Tor. P. (2019). Proximate and Mineral Analysis of Watermelon Sold at North Bank Market, Makurdi, Nigeria, *Global Journal of Science Frontier Research*, 19(1): 34-40.
- Gbakon, S.A., Ubwa, T.S., Ahilem, U.J., Obochi, O.G., Nwannadi, I.A. and Yusufu, M.I. (2018). Calcium Carbide Treatment on Some Physiochemical Characteristics of Broken and Mummy Mango Fruits. *American Journal of Food Technology*, 13(1):23-31.
- Gunasekara, S. R.W., Hemamali, K. G. U., Dayananada, T. G., and Jayamanne, V. S. (2015). Postharvest Quality Analysis of 'Embul' Banana Following Artificial Ripening Techniques, *International Journal of Science, Environment and Technology*, 4(6): 1625-1632.
- Hassan, S., Mazhar, W., Farooq, S., Ali, A., & Musharraf, S. G. (2019). Assessment of heavy metals in calcium carbide treated mangoes by inductively coupled plasma-mass spectrometry (ICP-MS). *Food Additives & Contaminants: Part A*, 36(12), 1769 - 1776.

- Islam, R., Antora, R. A., Monira, S. S. U., Islam, M. R., Alim, M. A. & Aziz, M. G. (2022). Assessment of Heavy Metal Residue, Physicochemical Properties, and Sensory Properties of CaC₂ Treated Banana. *Journal of Bangladesh Agricultural University*, 20(3): 333-340
- Izundu, A. I., Chukwuma, M. O., Adimonyemma, R. N., Akachukwu, E. E., and Iroka, F. C. (2016). Effects of Ripening Acceleration Methods on the Proximate, Biochemical and Mineral Compositions of Musa Paradisiaca (Plantain). *Ewemen Journal of Herbal Chemistry and Pharmacology Research*, 2(1): 26 - 33.
- Lestari, I. (2013). Effects of Carbide and CaC₂ Concentration on Vitamin- C Contents of Banana Kepok, *Folia Medica Indonesiana*, 49(2): 97-100.
- Maduwanthi, S. D. T. and Marapana, R. A. U. J. (2021). Total phenolics, flavonoids and antioxidant activity following simulated gastro-intestinal digestion and dialysis of banana (Musa acuminata, AAB) as affected by induced ripening agents. *Food Chemistry*, 33(9): 127-139.
- Majagi, J.N. and Jabannavar, V.B. (2019). Comparison of Vitamin "C" Levels in Naturally Ripened and Artificially Ripened Mangoes. *Journal of Health Sciences and Biomedical Research*, 11(1):25-27.
- Nuhu, A. M., Rabi, A., & Tukur, H. R. (2020). Proximate and elemental analysis of banana fruits (Musa Spp) ripened with various concentrations of calcium carbide. *Journal of Chemical Society of Nigeria*, 45(4), 648 - 655.
- Nura, A., Dandag, M.A., Wali, N.R. (2018) Effects of artificial ripening of banana (Musa spp) using calcium carbide on acceptability and nutritional quality. *Journal of Postharvest Technology*, 6:(2) 14-20
- Nwankwo, J. U., Osuji, C. A., Ubani, C. S. (2021). Human health risk assessment on the Consumption of Musa acuminata treated with different ripening agents. *Direct Research Journal of Health and Pharmacology* 9: 36-43
- Oguntade, B.K and Fatumbi T.C. (2019). Effects of Three Ripening Methods on the Proximate and Mineral Composition of Plantain (Musa paradisiaca) Fruits. *European Journal of Engineering and Technology*, 7(4):1-5.
- Okeke O., Aniobi, C. C., Akagha, I. C., Okoro, M. U., Nwosu, D.(2022). Proximate, phytochemical and heavy metal levels of selected ripened fruits sold in market outlets within Enugu metropolis, Enugu State, Nigeria. *Discovery*, 58(320), 914-920
- Oladipupo, A. R., Akinleye, M. O., & Coker, H. (2022). The Use of Calcium Carbide in Fruit Ripening: Health Risks and Arsenic Index as a Quantitative Marker for Calcium Carbide Residue. *Progress in Chemical and Biochemical Research* 2022, 5(2), 125-132
- Olubiyo, G.T., Obochi, V.U., Edogbanya, P.R.O., Olubiyo, C.K., Iyeh, V.A., Obaje, J.O. and Matthew, E.O.(2022) Evaluation of the Effect of Calcium Carbide as a Ripening Agent on the Nutritional Value and Heavy Metal Content of Banana and Orange. *Nigerian Agricultural Journal* 53(3): 16 - 21
- Paul, A. & Barman, A. K. (2024) Artificially Ripened Fruits - A Potential Danger *International Journal of Creative Research Thoughts* 12 (2): 931 - 935

- Salisu N., Umar, J., Abdulra'uf, M. S., Usman, M. B., Abubakar, H. and Kamba, M. R. (2022). Calcium Carbide (CaC_2) Induced Ripening on the Nutritional Value and Mineral Concentrations of Selected Fruits. *Savanna Journal of Basic and Applied Sciences (June, 2022)*, 5(1): 22-28
- Sojiru O.S., Biliaminu N.T., Mosaku A.M., Makinde K.O., Adeniji T.H. and Adeboye B.M. (2021). The implications of ripening agents on chemical compositions of plantain (*Musa paradisiacal*). *Heliyon*, 7:123-128
- Sogo-Temi, C.M., Idowu, O.A. and Idowu, E. (2014). Effect of biological and chemical ripening agents on the nutritional and metal composition of Banana (*Musa spp*). *Journal of Applied Science and Environment Management* 18(2): 243-246.
- Silva, L. D. & Barbosa, J. M. , (2009). Seaweed meal as a protein source for the white shrimp *Litopenaeus vannamei*. *Journal of Applied Phycology.*, 21(2): 193-197.