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Accelerated Ripening Agents and Their Effect on the Quality of Avocado (*Persia americana* M.) and Mango (*Mangifera indica L.*) Fruits

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Authors' contributions

This work was carried out in collaboration among all authors. Author CAO designed the study, author AEU performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author CIU managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

The natural process of fruit ripening is a combination of physiological, biochemical and molecular processes which can be activated or accelerated artificially by using different chemical agents. This study was carried out to examine the effects of three ripening process on the quality of avocado and mango fruits. Freshly unripe mango and avocado fruits were treated with calcium carbide powder, kerosene fumes and ripening in woven polypropylene bags. Calcium carbide treated fruits were stored for 48 hrs and all the samples were fully ripened except avocado fruit. The kerosene fumed fruits were stored for 24 hrs and then exposed to open air for another 24 hrs. Fruits ripened in empty plastic rice got ripened within 4 and 5 days for mango and avocado, respectively. The fruits were then analyzed for their physicochemical properties and sulphide and sulphate distributions using standard methods. The result revealed a decrease in TTA, pH, carbohydrate and vitamin C contents on ripening. On the other hand, moisture and TSS was observed to increase. However, accelerated ripening had no significant ($p<0.05$) effect on the moisture and

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vitamin C content of the fruits. Mango samples treated with calcium carbide recorded higher acidity (0.92%) and low pH (3.08) than those treated with kerosene (0.29% and 3.71%, respectively). Sulphide and sulphate distribution of avocado was found to increase after accelerated ripening with kerosene fumes. A decrease for sulphate (outer distribution) and increase for sulphate (inner) and sulphide (outer) was observed for mango fruits. The results also showed that ripening in woven polypropylene had no significant ($p<0.05$) effect on the TTA of the fruits while pH, moisture and TSS varied significantly ($p<0.05$) with fruit type. The use of calcium carbide for fruit ripening is not advisable.

Keywords: Fruits; ripening; mango; avocado; calcium carbide; kerosene fumes.

1. INTRODUCTION

Ripening is a normal physiological process that makes the fruit sweet, tasty, suitable for eating, nutritious and attractive [1]. Ripening is also associated with maturity and colour change due to the pigments that are already present or are produced during ripening. The ripening process involves several chemical and physical changes such as: Breakdown of starch present in the fruit to sugars resulting to a sweeter taste, changes in the skin of the fruit from green to red, yellow etc as a result of chlorophyll degradation [2,3]. Kendrick [4] and Bouzayen et al. [5] also reported that a number of developments take place as fruit ripen and become edible. These changes may take place while the fruits are still attached to the plant or after harvest.

Fruits can be classified as climacteric and non-climacteric fruits depending on the ripening behavior[6]. Climacteric fruits are fruits that continue to ripen after harvest such as pawpaw, mango, banana and avocado. They are harvested at a mature green but unripe stage and are edible until subsequent ripening processes have occurred [7]. In contrast, non-climacteric fruits once harvested do not ripen further such as pineapple, strawberry, orange and grape, these fruits stay on the tree or vine until ready to eat in order to have their desired characteristics [8].

Avocado (*Persia americana* M.) fruit is a tropical evergreen climacteric fruit belonging to the family Lauraceae [9]. The fruit originated from Mexico and South Central America and is found distributed throughout the world [10].The fruit is a large fleshy berry which is 5-15 cm long, ovate to spherical containing a single, hard nut shaped seed [11]. In Nigeria, the fruit is known as 'ebenmbakara' among the Ibibio/Efik and 'ubeoyibo' in Ojoto and neighbouring Igbo speaking communities of South East [12]. The fruit is serves as a source of various nutrients and especially as source of energy and monounsaturated fatty acids. Moozet al. [13] reported that about 70% of total fruit weight corresponds to the pulp.

Mango (*Mangifera indica L.*) is a tropical evergreen fruit tree spreading with dense rounded crown. The fruit is greatly cherished for its succulence, exotic flavour and delicious taste in most countries of the world [14]. The fruit is native to the Indian subcontinent and Southeast Asia widely cultivated in many tropical regions and distributed widely in the world [15]. The tree reaches a height of 35 - 40 m, with a crown radius of 10 m. The fruit takes from 3 - 6 months to ripen naturally. The fruit in it's ripen form varies in size and colour, and may be yellow, orange, red or green when ripe, depending on the cultivar [15].

The natural process of fruit ripening is a combination of physiological, biochemical and molecular processes [16]. This process can be activated or accelerated artificially by using different chemical agents [17,18,19]. Accelerated ripening is the premature ripening or speedy ripening of fruits due to external stimulus [20]. With modern technology, different techniques have been developed to artificially stimulate this ripening process which has become prevalent especially for commercial purposes to meet the high demands of consumers [19]. However, artificial fruit ripening is a matter of concern with various health-related issues [21] as different ripening agents such as ethephon, kerosene fume, calcium carbide, ethylene, amongst others are reportedly used to initiate the ripening process in fruits [22]. Artificial ripening agents are health hazardous and directly affect the ripening quality of fruits [23].

These days' fruits are ripened using various chemicals to meet their high demand and overcome transportation damage [24]. These chemicals affect our metabolism in one way or

the other and cause a number of health problems. According to Hossain et al. [25] and Mursalat et al. [26], direct exposureor direct consumption of artificial ripening agents in fruits poses possible health hazards to humans. Another major concern with accelerated ripened fruit is that these fruits have very low shelf life Ahmed et al. [27]. It is therefore important to identify and quantify anychange in nutritional values of artificially ripened fruits and also investigate any possible healthhazard associated with the consumption of these fruits.

2. MATERIALS AND METHODS

2.1 Identification and Collection of Samples

Avocado (*Perseaamericana*M.) and mango (*Mangiferaindica* L) and were harvested from the Rivers State University school farm in the month of April 2019. Identification of the materials was done by a plant scientist in the department of Crop and Plant Science, Rivers State University to ascertain that the right materials were used for the research. All chemicals used were of analytical grade.

2.2 Treatment on the Fruits

2.2.1 Calcium Carbide treatment on the fruits

Fresh unripe avocado and mango fruits were placed in a container (25 L rectangular). Then 10 g of calcium carbide powder was placed opposite the fruits in the container. The container was opened after 48 hrs and all the samples were fully ripened except avocado as shown in Fig. 1.

2.2.2 Kerosene fume

Fresh unripe avocado and mango fruits were placed in an airtight container (25 L round container). A flat-wick lighted kerosene lantern was placed at the center of the container and was allowed to burn until the oxygen inside was exhausted (the light went off in 10minutes). The samples were kept in the container for 24 hrs and then exposed to open air for another 24 hrs. All the samples were fully ripened after the 24 hours exposure to air as shown in Fig. 2.

2.2.3 Woven polypropylene bag

Fresh unripe avocado and mango fruits were separately tied in 25kg woven polypropylene bags and kept in a room. Mango and avocado fruits got ripen within 4 and 5 days, respectively as shown in Fig. 3.

2.2.4 Naturally ripened pawpaw

Fresh unripe pawpaw fruits (Fig. 4) obtained from the parent stock (tree) was allowed to naturally ripen at room temperature condition. Ripening took place after three weeks as shown in Fig. 5.

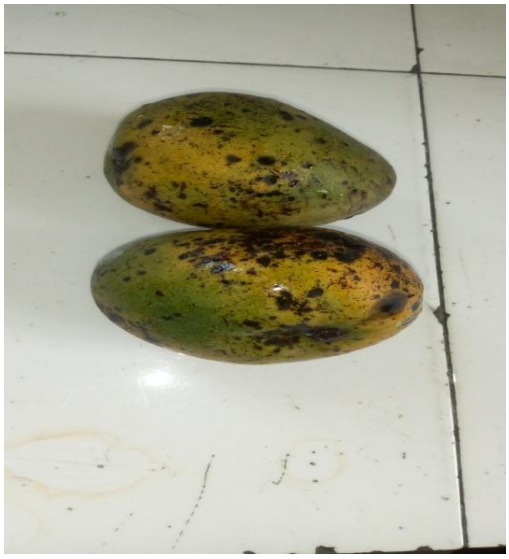

Fig. 1. Mango ripened with calcium carbide powder

2.3 Physicochemical Analysis

Moisture content, pH and Vitamin C content of the ripened fruits was carried out using the AOAC [28] method. Total available carbohydrate was determined usingthe manual Clegg Anthrone method of Osborne and Vogt [29]. The hand held sugar refractometer was also used in determining the total soluble solids (^{o}Brix) of the fruits. Total titratable acidity was determined by weighing 6g of the sample into a beaker and titrating each sample with0.1 N NaOH to an end point and then calculated [28].

2.4 Sample Preparation for Sulphide and Sulphate Analysis

The fruit samples were washed with distilled water and raised with deionized water. The outer layer was sliced in bits and grind to form a wide area concentration placed in conical flask and well labelled. The inner layer part of the seed (endosperm) was cut in cubes and grind.

Fig. 2. Kerosene ripened avocado pear (A), Kerosene ripened mango (B)

Fig. 3. Avocado pear ripened with woven polypropylene (A), Mango ripened with woven polypropylene (B)

Fig. 4. Unripe mango (A), Unripe avocado pear (B)

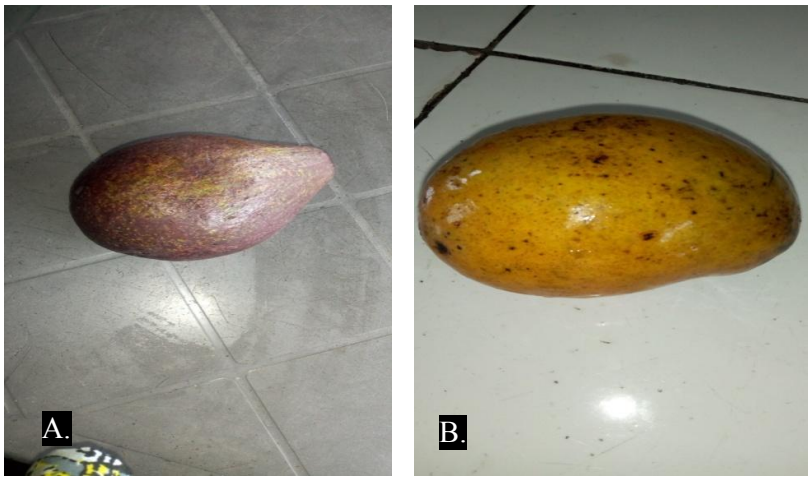

Fig. 5. Naturally ripened avocado pear (A), naturally ripened mango (B)

A known weight (2.0 g) was measured into a conical flask and 20.0 ml of deionized water set in mechanical shaker for 30 minutes. The filtrate was set taken to Hach Spectrophotometer for analysis as described below:

2.4.1 Sulphide analysis (methylene blue method. ASTM D4658)

Sulphide content was determined using the methylene blue method as described by Moest [30].

2.4.1.1 Reagents

Sulphide reagent 1&2
Sodium sulphide saturated solution: Hundred grams (100 g) of sodium sulphide hydrate was dissolved in 100 ml of distilled water.
Sulpide anti-oxidant buffer (SAOB): Eighty grams (80 g) of sodium hydroxide, 35 g of ascorbic acid and 67 g of EDTA was dissolved in 600 ml of distilled water and made up volume with distilled water.
Sodium sulphide stock solution: One mililitres (1.0 ml) of the saturated solution described above was pipette into 50 ml of SAOB and diluted to 1 litre distilled water.

2.4.1.2 Procedure

The stored program number for sulphide was entered. The display showed in mg/l S_2 and the zero icon. The sample was filtered since it was turbid. A clean cuvette was filled with 25 ml of the sample to be analyzed. Another sample cuvette was filled with 25 ml of distilled water which served as the blank. One mililitres (1 ml) of reagent 1 was added to both the blank and sample and swirl. One mililitres (1 ml) of reagent 2 was added to both the blank and sample and swirl. The timer was pressed and a five-minute reaction programe began. The cuvettes were then allowed to stand undisturbed. After the timer beeped, the blank cuvette was inserted into the sample holder and covered tightly. The ZERO icon was pressed. The sample was inserted and the READ icon pressed. The result displayed in mg/l S_2.

2.4.1.3 Calibration procedure

Four different concentrations were prepared.

Standard 1: Five mililitres (5.0 ml) of sodium sulphide stock solution and 50 ml of sulphide antioxidant buffer were measured and diluted to 100 ml with distilled water (0.1 ppm).
Standard 2: One mililitres (1.0 ml) of sodium sulphide stock solution and 50ml of sulphide antioxidant buffer were measured and diluted to 100 ml with distilled water (0.02 ppm).
Standard 3: Two mililitres (2.0 mls) of calibration standard 1 was measured and 50ml of sulphide antioxidant buffer added, diluted to 100ml with distilled water (0.002ppm).
Standard 4: One mililitres (1.0 mls) of 1.0mls of calibration standard 1 was measured and 50ml of sulphide antioxidant buffer added, diluted to 100 ml with distilled water (0.001ppm).

A calibration curve was prepared using concentration and absorbance reading.

2.4.2 Sulphate anlysis (turbidometric test method. ASTM D516-07)

2.4.2.1 Procedure

Sulphate content of the fruits was determined using the methylene blue method as described by Tabtabai [31]. A user-enter calibration is necessary to obtain the most accurate result. The stored program number for sulfate SO4 was entered. The display showed in Mg/L SO^4 and the ZERO icon. A clean sample cell was filled with 10 ml sample to be analyzed. The content of one sulfaver 4 sulfate reagent powder pillow was added to the sample cell. The cell was capped and inverted several times to mix. Press timer A 5 minute reaction program will begin. The cell was allowed to stand undisturbed. After the timer beeped, a second sample cell was filled with 10 ml of sample (the blank). The blank was placed into the cell holder. The sample cell was tightly covered with the instrument cap. The ZERO key was pressed and then display showed 0mg/L SO4. The prepared sample was placed into the cell holder. Tightly cover the sample cell with the instrument cap within five minutes after the timer beeps. The READ key was pressed and result was displayed in mg/l SO_4.

2.4.2.2 Calibration procedure

One thousand parts per million (1000 ppm) sulphate standard solution was prepared by dissolving 0.0256g of oven dried magnesium sulphate salt and diluted to 100 ml with deionized water. A 10ml pipette was used to add 1, 2,3,4,5 and 6 ml of the standard to the 100 ml volumetric flask, made up to mark with deionized water (ThisRepresents 10,20,30,40,50,and 60 ppm of the sulphate standards respectively). This was stopper and mixed well. The instrument was zeroed with water while each standard was analyzed using the photometer. The sulphate concentration increased by 10 mg/l for each 10 ml of standard added. The Calibration curve was plotted of absorbance against SO_4 concentration.

2.5 Statistical Analysis

All experiments and analysis were carried out in triplicates. The mean and standard deviation values were calculated. Data were subjected to Analysis of Variance (ANOVA). Means were separated using Tukey's multiple comparison test, and significance accepted at $P \leq 0.05$ level. The statistical package in Minitab 16 computer program was used.

3. RESULTS AND DISCUSSION

3.1 Physico-chemical Properties of Avocado and Mango Fruits as Affected by Accelerated and Natural Ripening

The physic-chemical properties of avocado and mango fruits as affected by accelerated and natural ripening is shown in Tables 1 and 2, respectively. Moisture content of the avocado fruit ranged from 76.39% in natural ripened avocado to 84.03% in unripe banana. For stored mango, moisture content ranged from 82.60% in unripe mango to 84.74% in kerosene fumed mango. Moisture content of unripe avocado and mango fruits was higher than samples treated with kerosene fume and natural ripened fruit. This showed that moisture content of the fruits increased during ripening. This is because of respiratory breakdown of starch to sugar, migration of water from peel to pulp and excess moisture formation [16]. Appiah et al. [32] reported that carbohydrates are hydrolyzed into sugars during ripening which increases osmotic transfer of moisture from peel to pulp. The differences in moisture behavior during ripening of avocado and mango fruits could be attributed to differences in their chemical composition. However, moisture content of the avocado and mango fruits were significantly ($p<0.05$) similar indicating that accelerated ripening had no effect on the moisture content of these fruit.

Titratable acidity gives a measure of the amount of acid present in a fruit. Total acidity of avocado and mango fruits ranged from 0.18-0.28% and 0.22-1.90%, respectively. There was a significant ($p<0.05$) difference observed with the unripe samples having significantly ($p<0.05$) higher total acidity. The result showed that ripening reduced the total titratable acidity of the fruits and this was more pronounced with natural ripened fruits. The decrease in acidity is due to susceptibility of the predominant acid to oxidative destruction as influenced by the ripening environment. Similar decrease was also reported by Appiahet al. [32] for mango fruit. This study correlates well with that of Muthal et al. [33] who reported that higher reduction of titratable acidity to be found in naturally ripened banana sample as compared to artificially ripened samples. Dhal and Sing [34] also reported a decrease in titratable acidity of tomato fruit (0.7-0.26%) using natural ripening. This study agrees to the fact that accelerated ripening of fruits results to decrease in the acidity. Enam et al. [35] and Fattah and Ali [21]

reported that low acidic fruits might cause dental erosion, especially among children. The avocado fruits ripened with kerosene had low acidity which indicates that it is safe to dental health. However, the calcium carbide ripened mango fruits had high acidity close to unripe fruits. Hence, the consumption of calcium carbide ripened mango fruit could be harmful to dental health.

pH of stored avocado ranged from 5.07 in natural ripened avocado to 6.40 in unripe avocado. pH of unripe avocado was higher and significantly different ($p>0.05$) from other samples. pH of mango from 3.08-4.40 and with kerosene fumed mango showing significantly higher ($p<0.05$) pH values than all other samples. A reduction in pH values was observed on accelerated ripening. These reductions was more pronounced for calcium carbide treated mango and naturally riped avocado pear fruits. The reduction in the pH on accelerated ripening is due to biochemical reactions which might have taken place in the calcium carbide and kerosene ripened fruits. Natural ripening of fruit involves multiplicity of biochemical pathways and the application of kerosene fume and calcium carbide as ripening agents for avocado and mango may probably have interfered with these biochemical pathways thereby affecting the pH of the fruits [36]. This study disagrees with the findings of Zenebeet al. [37] who reported significantly low pH values for banana fruits ripened through kerosene smoking systems. However, Chukumaet al. [38] reported high pH value for calcium carbide ripened banana (5.61) as compared to naturally ripened banana (5.31) and hot water ripened banana (5.36). Unuaegbu et al. [39] reported that fruits with a pH below 5 have been known to trigger dental erosion. All the fruits analyzed where acidic in nature with pH below above 5 for avocado fruits and as low as 3 for mango ripened with calcium carbide and kerosene. This may suggest that mango fruits ripened with calcium carbide and kerosene will accelerate dental erosion faster than avocado fruits.

Total soluble sugars (TSS) of avocado fruits ranged from 8.00°brix in unripe avocado to 11.00°brix in natural ripened avocado with natural ripened avocado showing significantly higher ($p<0.05$) TSS. TSS of the mango ranged from 8.00°brix in unripe mango to 13.70°brix in calcium carbide mango. There was a significant difference in the TSS of the mangoes with different treatments; however, TSS of calcium carbide mango was significantly higher ($p<0.05$).

Table 1. Physico-chemical properties of avocado as affected by accelerated and natural ripening

Samples	Total titratable acidity (%)	pH	Moisture (%)	Total soluble solids (°brix)	Total Available Carbohydrate (%)	Vitamin C (mg/100 g)
KFA	0.20±0.00^{b}	5.36±0.51^{ab}	84.03±2.06^{a}	9.05±0.07^{b}	0.94±0.03^{a}	0.002±0.00^{a}
NRA	0.18±0.00^{c}	5.07±0.04^{b}	76.85±12.21^{a}	11.00±0.00^{a}	0.96±0.46^{a}	0.003±0.00^{a}
UA	0.28±0.01^{a}	6.40±0.14^{a}	76.39±0.06^{a}	8.00±0.00^{c}	2.05±0.02^{a}	0.006±0.00^{a}

Values are means ± standard deviation of triplicate samples.
Mean values bearing different superscript in the same column differ significantly (P<0.05)
Key: KFA=kerosene fume Avocado, NRA=natural ripened Avocado, UA=unripe Avocado

Table 2. Physico-chemical properties of mango as affected by accelerated and natural ripening

Samples	Total titratable acidity (%)	pH	Moisture (%)	Total soluble solids (°brix)	Total Available Carbohydrate (%)	Vitamin C (mg/100g)
CCM	0.92±0.01^{b}	3.08±0.01^{d}	83.03±0.71^{a}	13.70±0.14^{a}	2.65±0.01^{c}	0.003±0.00^{a}
KFM	0.29±0.00^{c}	3.71±0.04^{c}	84.74±0.01^{a}	13.00±0.00^{b}	4.34±0.21^{b}	0.003±0.00^{a}
NRM	0.22±0.01^{d}	4.00±0.00^{b}	84.53±0.27^{a}	12.25±0.07^{c}	4.56±0.01^{b}	0.004±0.00^{a}
UM	1.90±0.01^{a}	4.40±0.00^{a}	82.60±2.96^{a}	8.00±0.00^{d}	5.24±0.01^{a}	0.005±0.00^{a}

Values are means ± standard deviation of triplicate samples.
Mean values bearing different superscript in the same column differ significantly (P<0.05)
Key: CCM=Calcium carbide mango, KFM=kerosene fume mango, NRM=natural ripened mango, UM=unripe mango

An increase in the TSS of the fruits was observed on accelerated and natural ripening. Increase in sugar may be due to breakdown of pectin and conversion of carbohydrate and conversion into simple sugars during storage caused by metabolic activities of the tissues [40]. It was observed from this study that TSS was higher for calcium carbide and kerosene mango fruits as compared to naturally ripened and unripe mango fruits. This was also reported by Chukumaet al. (2016). In their studies, TSS for calcium carbide banana (9.81%) was significantly higher than control (naturally ripened banana) of 5.39°brix. Islam et al. [41] also reported TSS of calcium carbide ripened banana (21.41°brix) to be higher than natural ripened banana (21.41°brix) while unripe banana was 9.64°brix.

Carbohydrate content of the mango ranged from 2.27-5.24% with unripe mango recording the highest while calcium carbide mango the lowest. Results also showed that carbohydrate content of unripe mango was significantly higher ($p<0.05$) than all other samples while the kerosene and naturally ripened banana were significantly ($p<0.05$) similar. This showed a decrease in carbohydrate content of the fruits on accelerated and natural ripening with pronounced decrease for calcium carbide ripened mango. Similar results was obtained for avocado fruits, but accelerated and natural ripening had no significant ($p<0.05$) effect on the carbohydrate content. The decrease in carbohydrate content during ripening is due to the hydrolysis of carbohydrates into sugars during ripening. Similar finding was reported by Appiahet al. [32].

Vitamin C content of mango ranged from 0.003mg/100g in unripe and kerosene fumed mangos to 0.005mg/100g in calcium carbide mango. The avocado had vitamin C content ranging from 0.002mg/100g in unripe avocado to 0.006mg/100g in natural ripened avocado. From the study, accelerated and natural ripening led to a decrease in the vitamin C content, however, it had no significant ($p<0.05$) effect on the vitamin C content of the fruits. The reduction in the vitamin C content of the fruit during ripening may be due to the susceptibility of ascorbic acid to oxidative destruction. Gbakun et al. [35] also reported that calcium carbide reduced the vitamin C content or mangoes as compared to naturally ripened mango. They reported that higher decrease in vitamin C in the calcium carbide treated mango compared to naturally ripened mango is probably due to accelerated action of calcium carbide during the ripening process. Dietary substances such as vitamins C, known to scavenge free radicals thereby removing them from the body are of importance to supplement the natural antioxidant defense system in oxidative stress conditions [42]. Onaegbu et al. [38] reported that ascorbic acid or vitamin C have been known to have other important functions in the body such as keeping α-tocopherol, a membrane bound antioxidant in its reduced state thereby enhancing its antioxidant activity. The results obtained from this study therefore shows that the use of calcium carbide and kerosene resulted to a decrease in this substance; hence its use should be minimized.

3.2 Sulphide and Sulphate distribution in the Fruits as Affected by Accelerated and Natural Ripening

The sulphide and sulphate distribution in avocado and mango fruits is presented in Tables 3 and 4, respectively. Sulphate distribution on the outer (fruit pulp) part of avocado were 1.23mg/kg and 2.63mg/kg for unripe and kerosene fumed avocados, respectively while that on fruit skin were 0.46mg/kg and 0.51mg/kg, respectively with kerosene fumed avocado recording higher sulphate content (on both skin and pulp). Sulphate content on the pulp of kerosene fumed avocado and unripe avocado fruits were significantly ($p<0.05$) similar while significant ($p<0.05$) differences were observed forsulphate content on the inner part. For sulphide distribution on the outer and inner parts, kerosene fumed avocado (1.95mg/kg and 3.03mg/kg, respectively) had sulphide contents significantly higher ($p<0.05$) than that of unripe avocado (0.008mg/kg and 0.010mg/kg for outer and inner parts, respectively).

Table 3. Sulphate and sulphide distribution (mg/kg) of avocado as affected by accelerated and natural ripening

Sample	Sulphate (Outer)	Sulphate (Inner)	Sulphide (Outer)	Sulphide (Inner)
KFA	2.63 ± 0.11^{a}	0.51 ± 0.08^{a}	1.95 ± 0.09^{a}	3.03 ± 0.11^{a}
UA	1.28 ± 0.25^{b}	0.46 ± 0.13^{a}	0.01 ± 0.01^{b}	0.01 ± 0.01^{b}

Values are means ± standard deviation of triplicate samples. Mean values bearing different superscript in the same column differ significantly (P<0.05); Key: KFA= kerosene fume Avocado, UA= unripe Avocado

Table 4. Sulphate and sulphide distribution (mg/kg) of mango as affected by accelerated and natural ripening

Sample	Sulphate (Outer)	Sulphate (Inner)	Sulphide (Outer)	Sulphide (Inner)
CCM	0.91±0.14[a]	1.18±0.04[a]	0.45±0.14[a]	0.38±0.09[a]
KFM	1.01±0.00[a]	0.72±0.00[b]	0.19±0.01[ab]	0.38±0.04[a]
UM	0.16±0.01[b]	0.66±0.01[b]	0.06±0.00[b]	0.000±0.00[b]

Values are means ± standard deviation of triplicate samples.
Mean values bearing different superscript in the same column differ significantly (P<0.05)
Key: CCM=Calcium carbide mango, KFM=kerosene fume mango, UM=unripe mango

Sulphate distribution on the outer skin of mango ranged from 0.91mg/kg in calcium carbide mango to 1.01mg/kg in kerosene fumed banana with no significant difference (p>0.05) observed for calcium carbide and kerosene fumed bananas. Sulphate distribution on the inner (fruit pulp) of the mango ranged from 0.72mg/kg in kerosene fumed mango to 1.18mg/kg in calcium carbide mango with no significant difference (p>0.05) observe for kerosene fumed and unripe mangoes. Sulphide distribution on the outer and inner parts of the stored mango ranged from 0.06-0.45mg/kg and 0.00-0.38mg/kg, respectively with calcium carbide and kerosene fumed mango showing significantly higher (p<0.05) sulphide content than unripe banana.

From the results, sulphate and sulphide were found to be high in calcium carbide and kerosene fumed fruits as compared to unripe fruit. This could be due to the diffusion of sulphate from calcium carbide and kerosene to fruit pulp and skin during ripening process. Khan et al. [43] reported that kerosene contains impurities like sulphate (emitted as Sox), aromatic compounds and hydrocarbons. Sulphate dioxide is used as a food additive in food for human consumption and generally regarded as safe [44]. However, Ken-Wen et al. [45] reported that sulphites can trigger asthma and other symptoms of allergic responses such as skin rashes and irritaions in sulphite-sensitive people. The maximum level of sulphites permitted by the Codex AlimentariusCommision [46] in fresh fruits with surface treatment is 50mg/kg. In this study, it was found that the sulphide and sulphate concentrations were below the limit indicating that the fruits were still safe for consumption against health threats posed by high concentrations of sulphate. Similar reports were reported by Islam et al. [41] who revealed a high amount of sulphate in calcium carbide ripened banana than the naturally ripened samples. They reported sulfate content in peel (36.7ppm) and flesh (23.3ppm) of carbide ripened banana to be higher than naturally ripened banana 926.7 and 10.0ppm, respectively. Similarly, sulphide content for calcium carbide banana on peel was 0.0867ppm while that of naturally ripened banana was below detection limit (BDL).

3.3 Chemical Properties of Avocado and Mango Ripened and Stored in Woven Polypropylene Bags

Table 5 shows the chemical properties of avocado and mango fruits ripened and stored in woven polypropylene bag. pH values of the fruits stored in woven polypropylene bag were 5.09 and 3.95 for woven polypropylene bag ripened avocado and mango fruits, respectively with significant differences (p<0.05) observed in these values. Total titratable acidity recorded 0.17% and 0.24% for woven polypropylene bag ripened avocado and mango fruits, respectively with no significant difference (p>0.05) observed in these values. For TSS, the stored fruits had TSS recording 6.30^{o}Brix and 13.00°Brix, respectively with significant (p<0.05) differences observed. Moisture content of the fruits recorded 79.93% in woven polypropylene bag ripened avocado and 84.08% bag in woven polypropylene bag mango with significant difference (p<0.05) observed

Table 5. Physico-chemical Properties of Avocado and Mango fruits stored in woven polypropylene bags

Samples	TTA (%)	pH	Moisture (%)	TSS (^{o}brix)
RBA	0.17±0.04[a]	5.09±0.04[a]	79.93±7.38[b]	6.30±0.00[b]
RBM	0.24±0.00[a]	3.95±0.07[b]	84.08±0.12[a]	13.00±0.00[a]

Values are means ± standard deviation of triplicate samples.
Mean values bearing different superscript in the same column differ significantly (P<0.05)
Key: RBA= woven polypropylene bag avocado, RBM= woven polypropylene bag mango

in these values. The significant difference ($p<0.05$) in pH, moisture and total soluble solids of the fruits is due to their differences in chemical composition. Abel and Aidoo [47] reported that significant differences observed between the sugar content of fruits could be attributed to variation in the enzymatic activities of the fruits.

4. CONCLUSION

The study showed that natural and accelerated ripening of avocado and mango fruits resulted to a significant decrease in pH and acidity. This decrease was significantly higher for unripe fruits followed by mango ripened with calcium carbide. The pH values of mango treated with calcium carbide and kerosene were significantly low while acidity of calcium carbide ripened mango was high. This could have health implications such as dental decay. Therefore, the use of calcium carbide for ripening of mango should be discouraged. A decrease in carbohydrate and vitamin C contents on ripening along with raise in moisture and total soluble solids (TSS) was observed. However, accelerated ripening had no significant effect on the moisture and vitamin C content of the fruits. Sulphate and sulphidewere found to be high in calcium carbide and kerosene fumed fruits as compared to unripe fruit. However, it was found that the sulphide and sulphate concentrations were below the limit indicating that the fruits were still safe for consumption against health threats posed by high concentrations of sulphate. This study has also showed that ripening of the fruits in woven polypropylene bags had no significant effect on the TTA of the fruits while pH, moisture and TSS varied significantly with fruit type.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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